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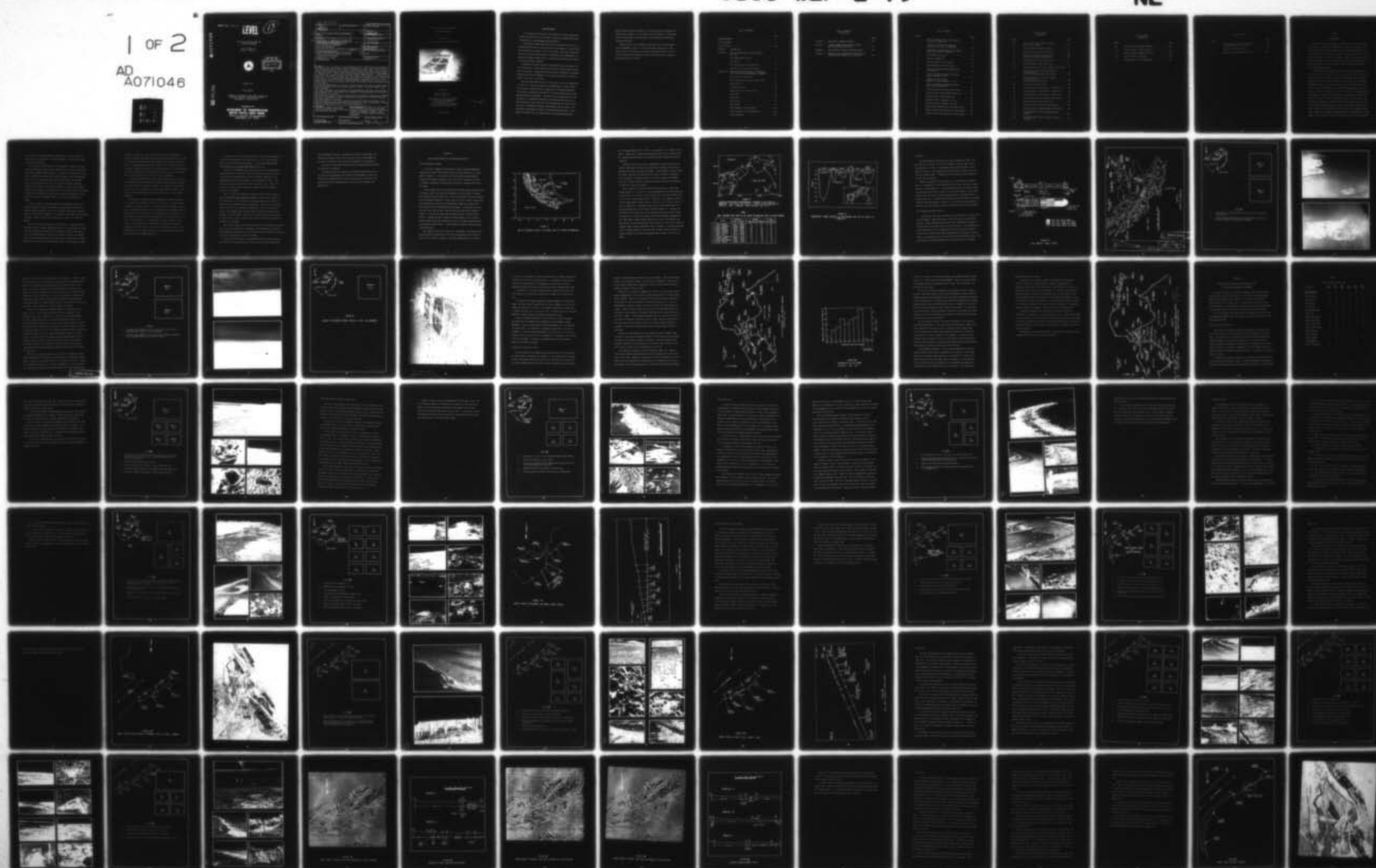

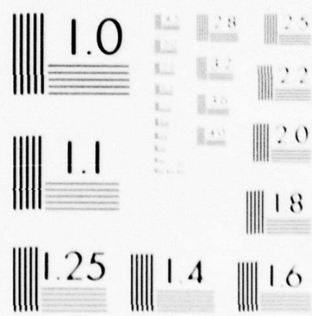

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FATE OF OIL SPILLED FROM THE
SUPERTANKER METULA

ROY W. HANN, JR.
HARRY N. YOUNG, JR

JANUARY 1979

FINAL REPORT

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Prepared for

DEPARTMENT OF TRANSPORTATION
UNITED STATES COAST GUARD
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16. Abstract

On 9 August 1974, the METULA, a 206,000 deadweight VLCC (Very Large Crude Carrier) enroute from Ras Tenura, Saudi Arabia to Quintera Bay, Chile, with a load of 195,673 tons of Arabia light crude, ran aground on the Satellite Patch Shoal in the Straits of Magellan, Chile. The oil spill was destined to become the world's second largest as of that time, exceeded only by the famous TORREY CANYON disaster. In terms of oil deposited on the shore, the METULA spill may be the world largest, since the geography of the area, the prevailing winds, and the nearness of the grounded ship to shore caused most of the oil to reach the Chilean shoreline primarily on the shore of the famous Island of Tierra del Fuego, which forms the southern shore of the eastern half of the Straits.

The greatest significance of this spill results from the fact that no cleanup operation was attempted and thus the spill became by default, the worlds largest scientific oil spill.

This report describes the oceanographic and meteorological setting of the grounding and subsequent spill and discusses the grounding, the resulting spill and the deposition of the oil on shore.

An in-depth discussion of fifteen selected sites is presented including environmental features, the deposited oil and its appearance and behavior at different times and the visual impact of the spill.

The final section of this report addresses the lessons learned at the time of the spill and subsequently and discusses the development of pilot international training efforts to help countries plan to deal with such spills.

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FATE OF OIL SPILLED FROM THE SUPERTANKER METULA

Final Report

U.S.C.G. Project No. DOT-CG-62281-A

prepared by

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January 1979

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Of particular significance has been the collaboration of the administration and staff of the Instituto de la Patagonia in Punta Arenas who joined with the author in each field study. Particular thanks are directed to Director Mateo Martinic; Scientists Italo Campodonico, Leo Guzman and Claudio Venegas and U.S. Peace Corps Volunteers Bill Texera, Jean Texera and Steve Langley.

Throughout the study excellent relationships were maintained with the Chilean Navy. Special thanks are directed to Admiral LeMay and his staff in Santiago, Commandant Francisco Pizarro in Valparaiso and Admiral Eduardo Allen who was Commander of the Third Naval District in Punta Arenas at the time of the spill.

The author was asked as part of this study to seek the cooperation of other U.S. scientists working on the METULA Spill so that foreign trips could be coordinated and a common base of knowledge generated. The voluntary cooperation furnished by all those participating in this program has been outstanding. The author is very appreciative of the fine spirit of cooperation exhibited by Miles Hayes and his staff at the University of South Carolina, Dale Straughan and her staff at the University of Southern California, Rita Colwell and her staff at the University of Maryland, Ed Owens of Louisiana State University, Scott Warner of Battelle N.W. and Joseph Rule of Old Dominion University,

Charles Gunnerson and John Emerick of National Oceanic and Atmospheric Administration (NOAA), Victor Gallardo of the University of Concepcion (under Environmental Protection Agency (EPA) funding) and Ken Adams (formerly with EPA).

Appreciation is also expressed to Charles Bates, Science Advisor to the Commandant of the U.S. Coast Guard whose vision led to this project and to Jim Atkinson, Joel Sipes and Charles Corbett of the U.S. Coast Guard Marine Environmental Protection Office who have supported and worked with this project.

TABLE OF CONTENTS

TABLE OF CONTENTS
(Continued)

LIST OF FIGURES

LIST OF FIGURES
(Continued)

LIST OF FIGURES
(Continued)

LIST OF TABLES

SECTION I

INTRODUCTION

When dawn broke on the morning of August 10, 1974, in the windswept First Narrows of the Strait of Magellan, it revealed the stranded hull of the once-proud supertanker METULA, which had plowed aground on Satelite Patch Shoal late the previous night. This was a sad fate for a ship feted as recently as June 6 as the guest of honor at the opening of the Caribbean Deepwater Curacao Oil Terminal near Venezuela and featured as the center spread in the then current issue of the Shell Oil Company house organ, The Shell News.

The METULA had been proceeding from Ras Tenura in Saudi Arabia on the Persian Gulf to Quintero Bay, Chile with a load of over 196,000 tons of light Arabian crude oil for ENAP, the Chilean National Oil Company. The METULA, with its 1,067-foot length, 62-foot draft, and 206,000-ton deadweight capacity, was the first ship of the VLCC (Very Large Crude Carrier) class or supertanker of over 200,000 deadweight tons to be involved in a major oil spill of this size. The cause of the grounding has been debated in and out of hearings and reported in other publications. It will suffice to say that the debates revolve around the severe tide and current conditions of the First Narrows area of the Strait, the cold blustery winds blowing toward the bridge of the tanker during the long winter nights of the high latitudes, the difficulty of navigating this large a ship with a minimum of navigation aids, the minimization of known dangers close at hand in the face of hidden shoals several miles ahead,

and a variety of factors leading to human error. For the purpose of this study it is adequate to say that the METULA, a 60-foot draft ship, struck a 40-foot shoal.

The oil spill, which began late on the night of August 9, was destined to become the world's second largest as of that time, exceeded only by the famous TORREY CANYON disaster. In terms of oil deposited on the shore, the METULA spill may be the world's largest, since the geography of the area, the prevailing winds, and the nearness of the grounded ship to shore caused most of the oil to reach the Chilean shoreline primarily on the shore of the famous Island of Tierra del Fuego (Land of the Fire), which forms the southern shore of the eastern half of the Strait of Magellan. The METULA was eventually refloated on September 25, 1974, and left the Strait of Magellan under tow to Isla Grande near Rio de Janeiro.

On the second day of the grounding, when the METULA swung to starboard and holed and flooded its engine room compartments, the need of external pumping systems to remove the remaining cargo became imperative. The U.S. Coast Guard, responding to a request for assistance by the Chilean Government, played a major role in limiting the loss of oil from the METULA.

The initial spill was reported to be 6,000 tons. Subsequent spills continued, with the largest being 20,000 tons on or about August 19, until the total reported spill quantity of 51,500 tons of light Saudi Arabian crude oil and approximately 2,000 tons of Bunker C fuel oil was reached. The oil would initially spread over large areas of Bahia Felipe and Bahia Gregario to the west of the First Narrows and to a lesser degree to Bahia

Posession to the east. The initial dispersion was predominantly by gravity spreading superimposed on the local currents, which were as high as ten knots from spring tides which ranged on the order of 10 meters (30 ft). Northwesterly winds on the order of 30 to 50 knots drove the floating oil ashore, primarily on the southern shore of the First Narrows and on the southern shore of Bahia Felipe, and later onto the southern shore of the continent east of the site of the grounding.

The greatest significance of this spill results from the fact that no cleanup operation was attempted and thus the spill became by default, the world's largest scientific oil spill. As scientists realized this fact, there was a major interest to study this spill to observe if and when the natural environment would return this area to its pre-spill condition.

The author's involvement with the METULA spill began on August 23, 1974, when he was requested by the U.S. Coast Guard to accompany their contingency as science advisor. His role was to lend technical assistance on cleanup operations, if any, evaluating future equipment needs for high-speed current oil recovery and evaluating the fate and effect of the spilled oil with regard to its importance to the United States as it enters the supertanker era, particularly in colder climates. Since cleanup of this spill was not undertaken, attention was focused on learning the fate and effect of the oil. The results of this trip were published by the U.S. Coast Guard both as a separate report (3) and as part of their overall METULA Report (1).

In January of 1975 the author returned to the spill site under U.S. Coast Guard sponsorship as the Coordinator of a U.S. Team with NOAA, NOAA contractor and EPA participation. A report entitled Follow-Up Field Studies from the Supertanker METULA ensued (5).

Interest in the METULA spill stayed alive and was strengthened by a NOAA Conference in Boulder in June of 1975 and a conference entitled Preservacion del Medio Ambiente Marino in Santiago sponsored by the Department of International Studies of the University of Chile. Excellent reports were published by both conferences (4,6). These conferences and other factors spurred the funding of several projects relating to the METULA.

The U.S. Coast Guard funded the author's project entitled Fate of the Oil Spilled from the Supertanker METULA for which this document is the final report. Other projects in the United States were funded by NOAA, EPA and the National Science Foundation. Each of the six projects funded had both U.S. and Chilean collaboration. The U.S. Coast Guard project and the NOAA project worked primarily with the Instituto de la Patagonia in Punta Arenas. Details of the projects other than this one are discussed in a later section of this report and project abstracts are included as an appendix.

This report consists of this introduction and four additional sections. Section II will describe the oceanographic and meteorological setting of the grounding and subsequent spill and will discuss grounding, the resulting spill and the deposition of the oil on shore.

Section III will include an in-depth discussion of fifteen selected sites that were visited during one or more trips from 1974 through 1978.

The environmental features, the deposited oil and its appearance and behavior at different times after the spill and the visual impact of the spill as observed by the principal investigator are presented.

Section IV of the report will discuss the companion projects which are underway or completed.

The final section will address the lessons learned at the time of the spill and subsequently, will discuss the development of pilot international training efforts to help countries plan to deal with such spills and provide recommendations for future action regarding the METULA spill.

SECTION II

THE SITE AND DETAILS OF THE GROUNDING AND SPILL

The Environmental Systems

The Strait of Magellan, discovered in 1520 by Ferdinand Magellan, connects the Atlantic and Pacific oceans near the southern tip of South America (Figure 1). On the west it cuts the igneous and metamorphic ranges of the Andean Cordillera, and on the east it separates the flat or slightly undulating, fluvio-glacial terrains of Patagonia and Tierra del Fuego.

In the eastern third of the Strait the intertidal zone consists mostly of shingle, gravel, and sand, with mudflats and salt marshes in places, and occasional areas of hard clay. Back from the shore there are morainal till and extensive deposits of loess, which form tall cliffs in some areas. The ground surface often has strong parallel ridges and elongate salt pans aligned with the prevailing westerly winds. In appearance the area is a low, flat, bald prairie, covered with bunch grass and occasional bushes. It is an arid region with an annual rainfall of about 300 mm (12 in). Towards the west, beyond the Second Narrows, hills formed by glacial debris become more numerous, and near the Andean Cordillera they are covered by dense timber. In this region the annual rainfall exceeds 1,500 mm (60 in).

The climate of the area is that of a cold steppe: The mean air temperature near the Atlantic is 6.7°C (44°F) varying from 2.5°C (36°F) in July to 11.7°C (53°F) in January. The water temperatures in the Strait

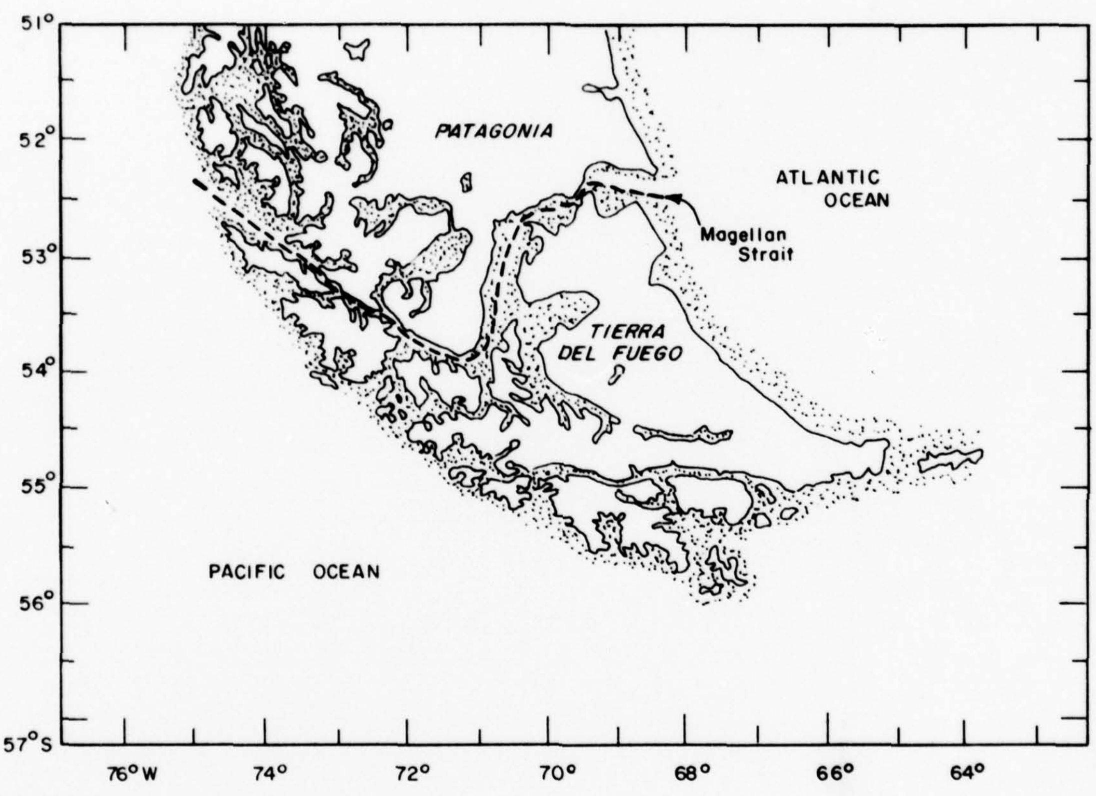


FIGURE 1

MAP OF PATAGONIA, TIERRA del FUEGO, AND THE STRAIT OF MAGELLAN

vary from approximately 9.5°C (49°F) in the summer to 3.5°C (38°F) in the winter. Summer water temperature measurements show little variation and the comparison between surface and subsurface values indicate well-mixed conditions.

The eastern half of the Strait of Magellan is noted for its exceptionally high winds, varying from southwest to northwest with force and frequency increasing in spring and summer. Winds commonly exceed 20 m/sec (40 knots), and gale and hurricane-force winds of 50 m/sec (100 knots) occur frequently. During the period of the oil releases from METULA, 35 m/sec (70 knots) winds occurred several times, and once were reported in excess of 57 m/sec (115 knots).

Water currents in the First Narrows are mostly due to tides with average ranges of 7.3 m (24 ft) at Punta Dungeness in the eastern entrance of the Strait, 8.5 m (28 ft) at the eastern end of the First Narrows, and 1.2 m (4 ft) at Punta Arenas (Table 1, Figure 2). The ranges of spring tides in these same locations are 9.1 m (30 ft), 10.4 m (34 ft), and 1.5 m (5 ft), respectively. Maximum currents occur in the narrows where the cross-sectional area of the Strait is reduced (Figure 3). Currents calculated from tide table data for the spill period varied from 4.4 m/sec (8.5 knots) to 4.8 m/sec (9.3 knots) in the First Narrows, depending on the tidal range in Bahia Felipe, where most of the oil was spilled and went ashore, the daily spring tides were as high as 4.6 m (15 ft), and the computed tidal currents approached 3 m/sec (6 knots). The actual distribution of currents (both at the surface and at depth) within the bays is largely affected by the bottom topography and the winds, as well as by tides.

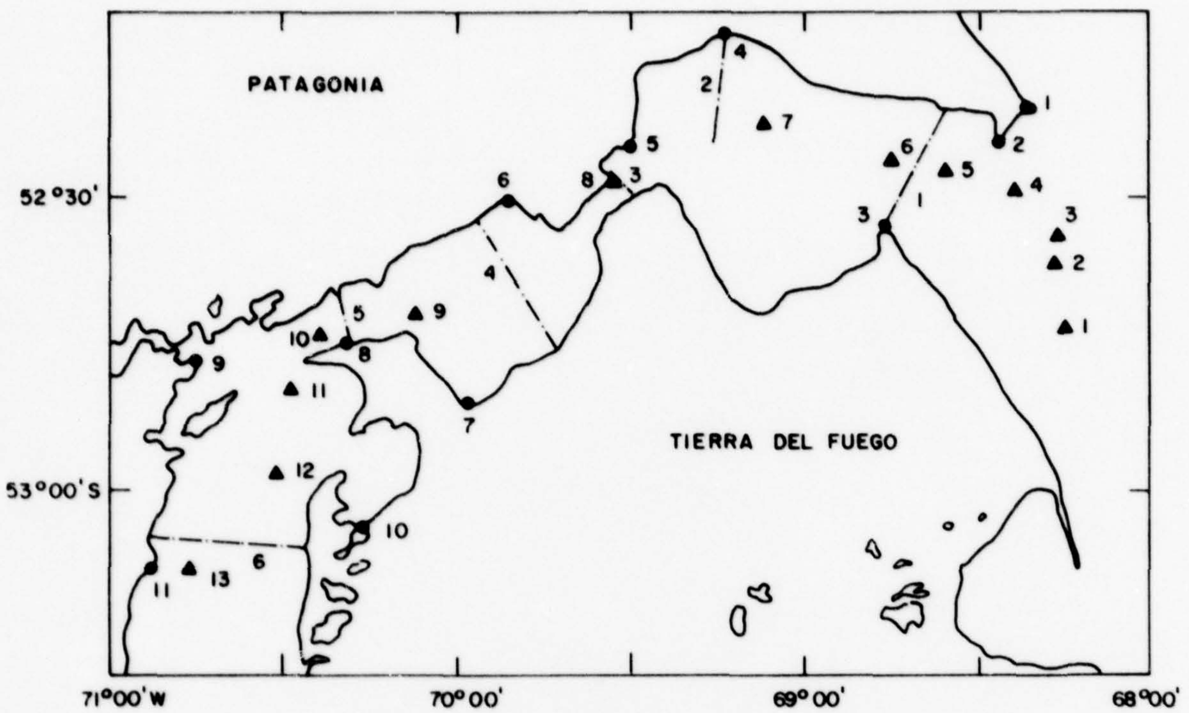


FIGURE 2

LOCATION OF SELECTED OCEANOGRAPHIC STATIONS IN THE STRAIT OF MAGELLAN. SOLID CIRCLES = TIDE STATIONS ; TRIANGLES = BATHYTHERMOGRAPH (BT) STATIONS ; LINES = NUMBERED CROSS SECTIONS (SEE FIG. 6)

TABLE I

TIDAL STATIONS AND DATA IN THE STRAIT OF MAGELLAN EAST OF PUNTA ARENAS

	PLACE	*POSITION*		*RANGES*		*MEAN*
		LAT.	*LONG.*	*MEAN (m)*	*SPRING (m)*	*LEVEL (m)*
1	CABO VIRGENES	52°21'	68°22'	7.3	9.1	5.9
2	PUNTA DUNGENESS	52°24'	68°26'	7.3	9.1	5.1
3	PUNTA CATALINA	52°32'	68°46'	6.9	8.7	5.1
4	BAHIA POSESION	52°16'	69°10'	8.4	10.2	6.1
5	BANCO DIRECCION	52°24'	69°26'	8.5	10.4	6.4
6	BAHIA SANTIAGO	52°31'	69°52'	4.3	5.4	3.2
7	BAHIA FELIPE	52°47'	69°57'	3.7	4.6	2.9
8	SEGUNDA ANGOSTURA	52°45'	70°18'	4.9	6.2	3.9
9	PUERTO ZENTENO	52°47'	70°46'	1.4	1.8	1.3
10	BAHIA GENTE GRANDE	52°03'	70°16'	1.9	2.3	1.5
11	PUNTA ARENAS	53°09'	70°54'	1.2	1.5	1.2

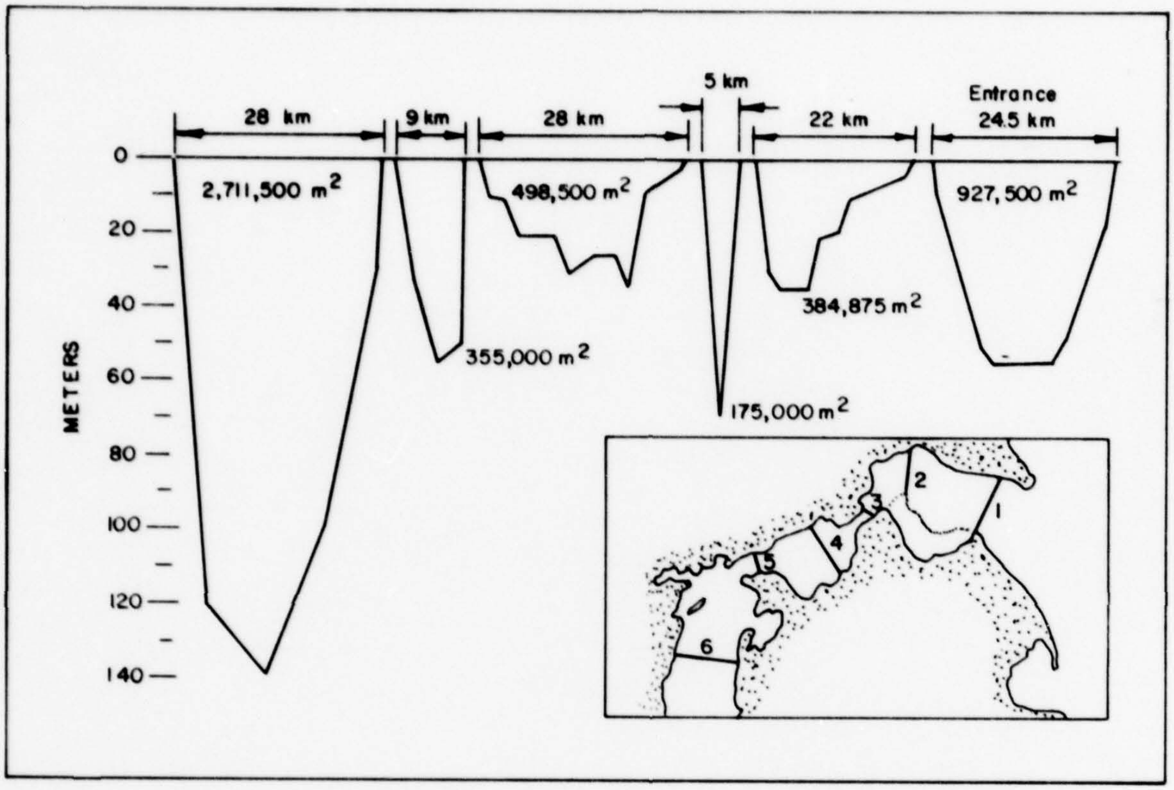


FIGURE 3

TOPOGRAPHIC CROSS SECTIONS IN THE EASTERN HALF OF THE STRAIT OF MAGELLAN

The METULA

The VLCC METULA was constructed in Japan, completed in 1969. She was 1067 feet in length, 155 feet in breadth, 80 feet in depth, with a loaded draft of 62 feet. In deadweight, she was 210,027 metric tons or 206,719 long tons. Her propulsion was steam turbine, single screw, and she had a single rudder. A diagram of the ship and its tank configuration is shown in Figure 4.

METULA was owned by Curacao Tankers (N.V. Curacaosche Scheepvaart Maats.), a subsidiary of the Royal Dutch Shell Group. She was on demise charter to Shell Tankers B.V., Rotterdam, and was trip-chartered by Shell International Marine (SIM), London, to carry an FOB cargo of light Saudi Arabian crude oil from Ras Tenura, Saudi Arabia, on the Persian Gulf to Quintero Bay, Chile, for Empresa National del Petroleo (ENAP)--The Chilean National Petroleum Company....which is to say that the cargo belonged to ENAP but was in the custody of Royal Dutch Shell when the ship grounded.

The Grounding and Resulting Spill

At 2220 local time (zone time GMT +4) on Friday night, 9 August 1974, the VLCC METULA, loaded with about 194,000 long tons of light Arabian crude oil, while westbound through the Strait of Magellan, grounded on Satellite Bank at the west end of the First Narrows. The grounding location (latitude 52°-33.8'S, longitude 69°-42.1'W) is shown in Figure 5. Figure 6 Part A and B shows aerial photographs of kelp beds on Satelite Patch at a similar time in the tidal cycle as when the METULA struck. The kelp fronds are shown streaming with the current and show a definite

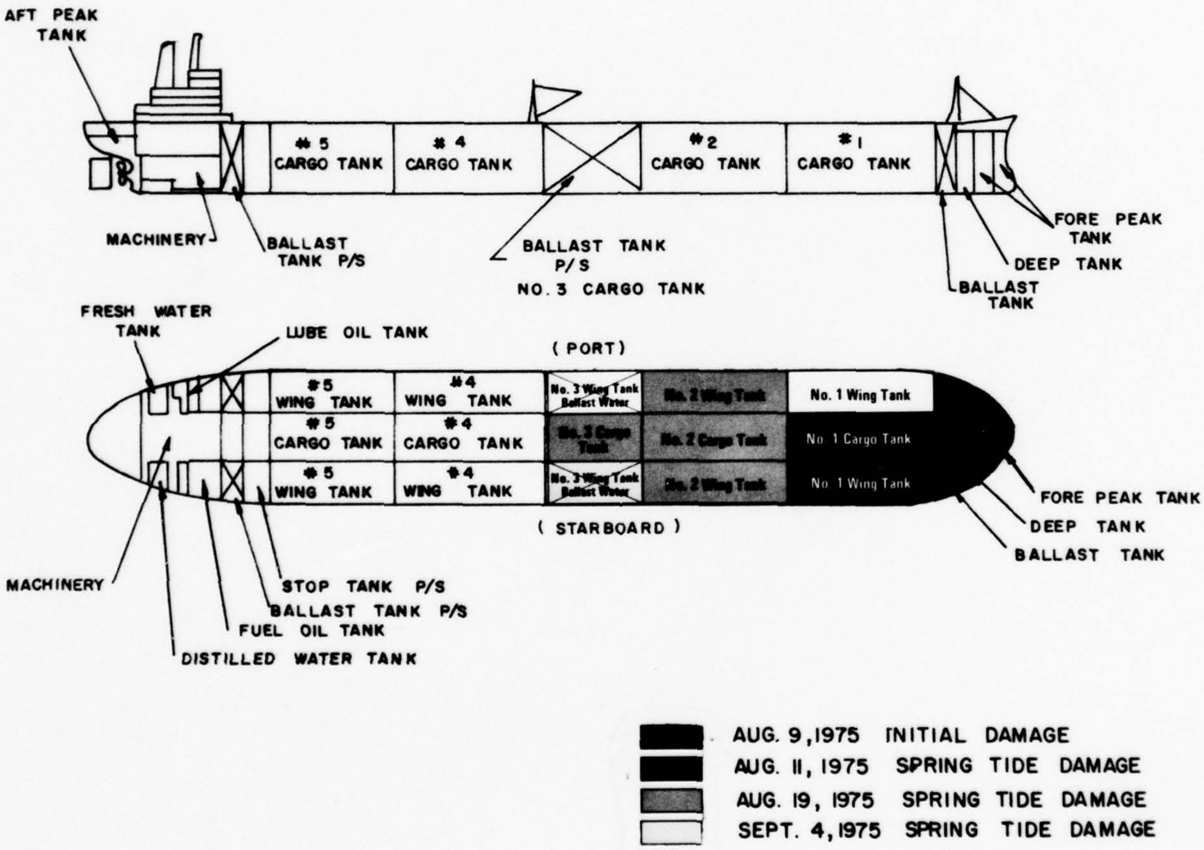


FIGURE 4

VLCC *METULA* TANK LAYOUT

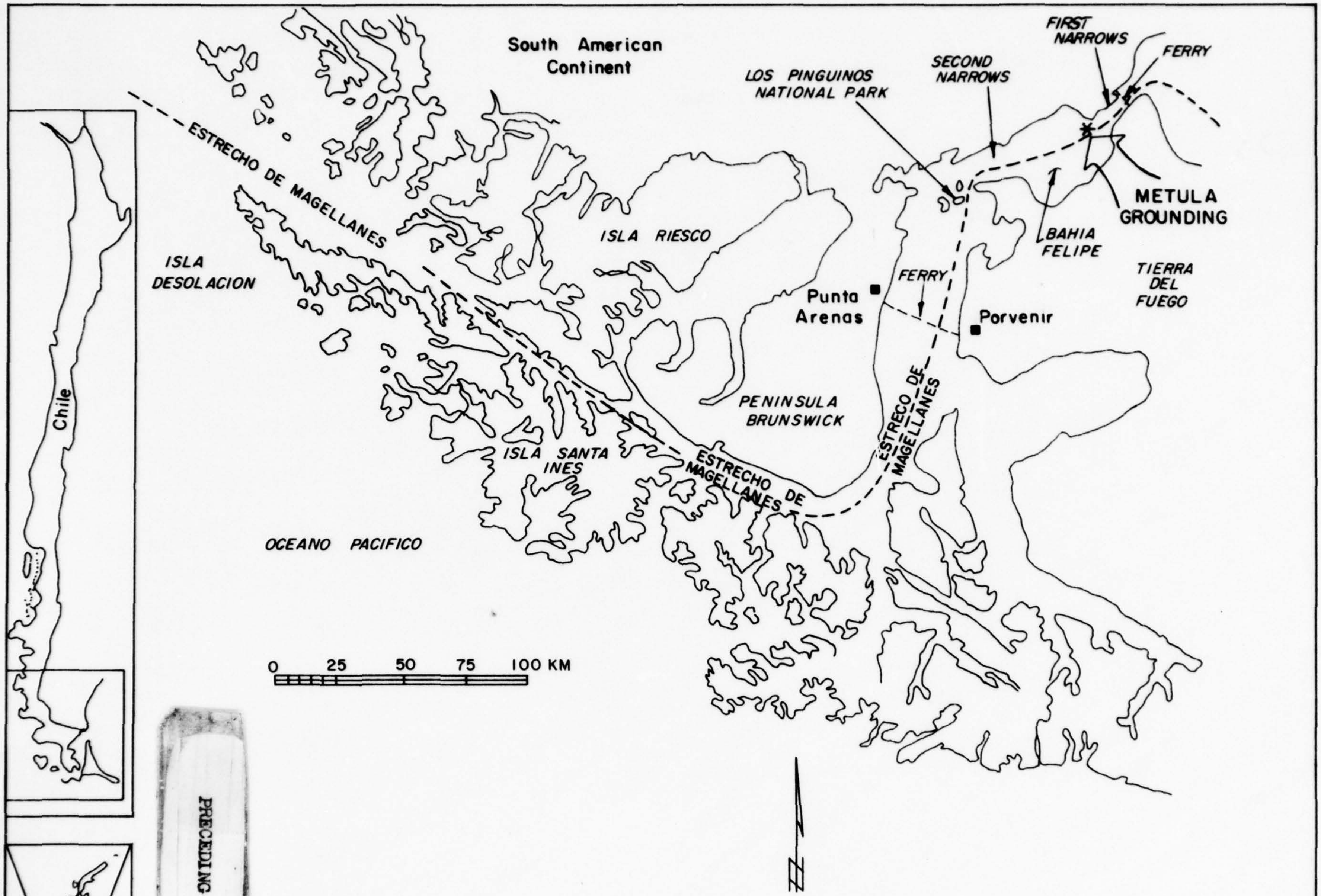
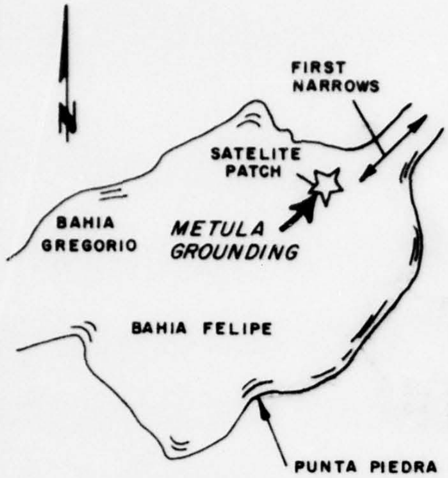


FIGURE 5

STRAITS OF MAGELLAN



PART A
1/77

PART B
1/77

FIGURE 6

A - View of kelp in Satelite Patch at west end of First Narrows looking east.

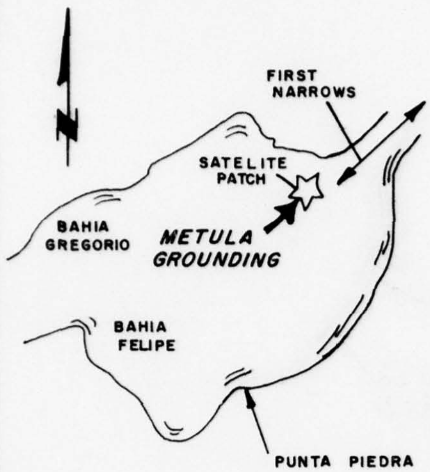
B - Close-up aerial photograph of kelp bed showing flow lines of surface currents at acute angle to channel.

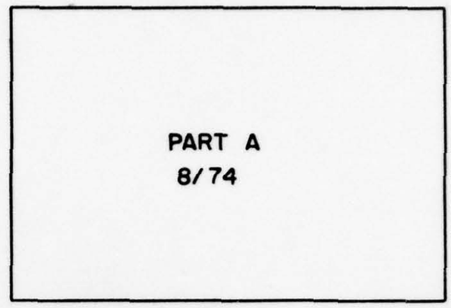
10/110

pattern to the side of the channel toward the northeast. A theory is that this current acted on the broad side of the ship when it wandered toward the side of the channel and helped push the ship into the side of the shoal. The ship is reported to have struck bottom at nearly her full speed of 14.5 knots, coming to a stop in about 260 feet -- with an action described as "like a shock wave." In the initial impact several forward compartments were breached, including the forepeak, forward deeptanks (containing Bunker C), forward ballast tank, and cargo tanks #1 center and starboard. About 6,000 tons of oil was initially released.

Figure 7 Part A shows the grounded tanker as it appeared in late August of 1974. In the initial picture, the close proximity of the shoreline can be seen. Figure 8 is a closeup of the grounded METULA. At first the ship held fast on her original grounding heading of 235° True, apparently resting on the area of #2 cargo tank; however, on Sunday afternoon at about 1600 local time, August 11, 1974, the stern was swept to starboard under the force of the strong flood tide current at high tide, grounding the after end of the ship and reportedly holing it in three places. In about one hour the engine room and steering engine room were filled, killing all power. The ship was held in place on the edge of the steep, rocky reef on a heading of about 185° True, which position was maintained thereafter despite high winds and cross-currents running to eight knots.

The loss of cargo increased due to the action of tides and current. Then on about August 19, during the spring tides, four additional compartments -- tanks #2 across and #3 center -- were opened to the sea. During the following spring tide cycle, on about September 4, tank #3 starboard (a clean ballast tank) and the starboard bunker tank were reported open





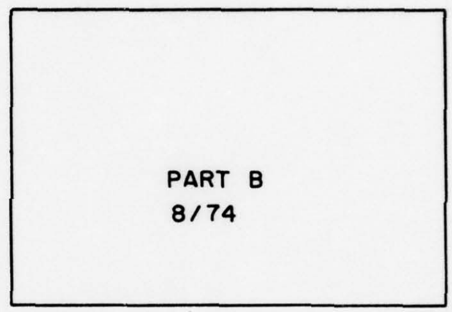


FIGURE 7

A - Grounded tanker METULA on Satelite Patch with south shore of South American Continent in the background.

B - Grounded tanker METULA with lighting tanker HARVELLA alongside. Oil is shown spreading over the water surface.

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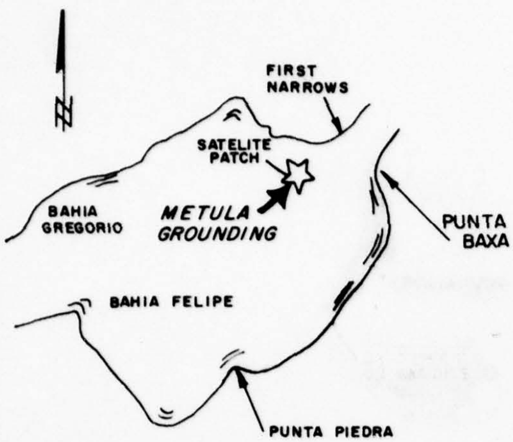
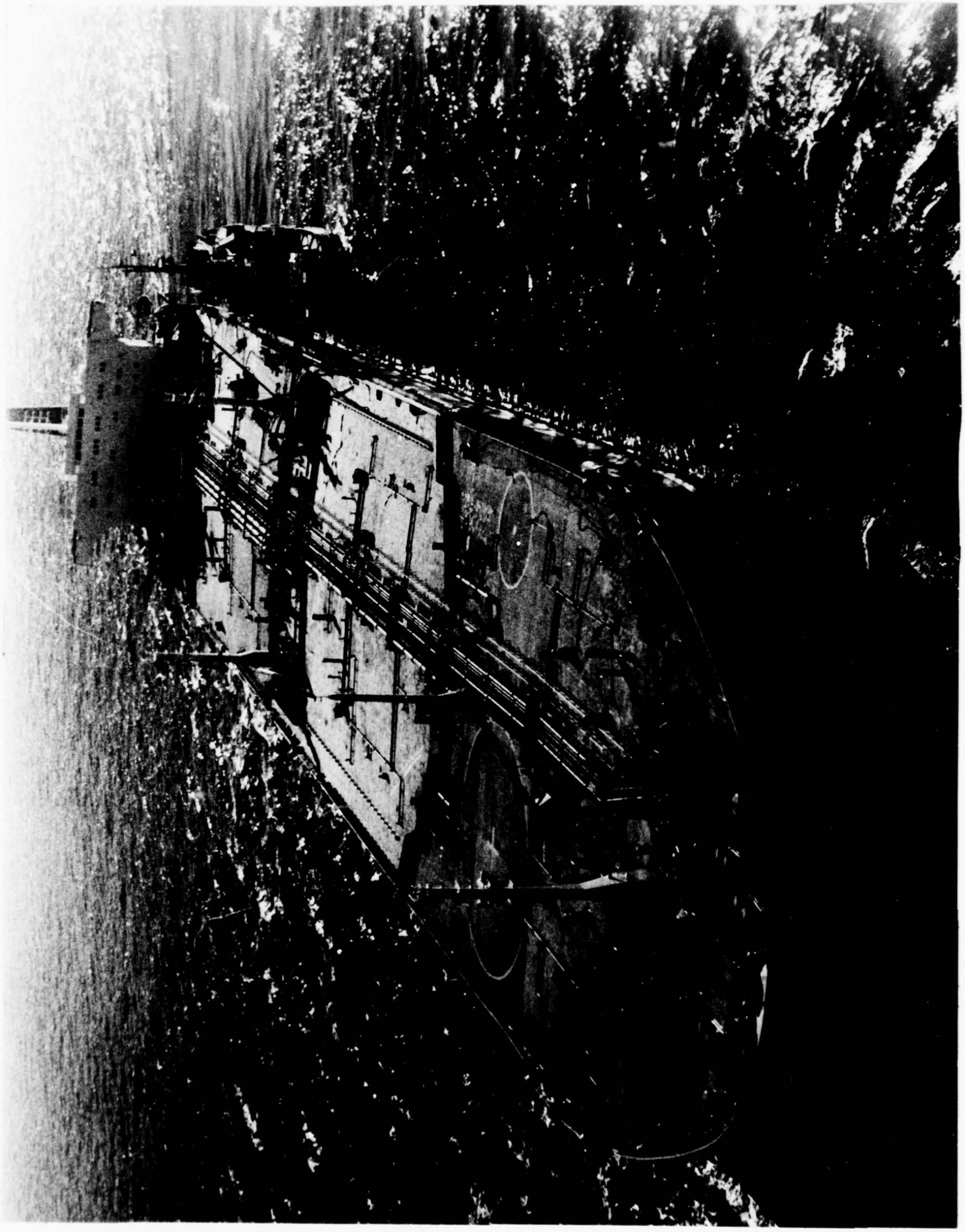


FIGURE 8

8/ 74

FIGURE 8

CLOSEUP OF GROUNDED TANKER *METULA* WITH TUG ALONGSIDE



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to the sea. On September 23 there was indication of leakage from tank #4 center with a low rate of ullage increase. In addition to these spills, there were varying rates of oil seepage off and on from the time of grounding through the refloat operation, most severe during lowest tides.

On August 15, it had been estimated that 20,000 tons had been lost. As of August 22, it had been estimated that 40,000 tons of oil had been lost.

On August 29, the small Argentinean tanker HARVELLA of 19,000 deadweight tons was brought alongside and the initial pumping of oil from the METULA was carried out as part of the attempt to minimize pollution and to remove sufficient oil to float the ship. In Figure 7 Part B, the tanker HARVELLA is shown alongside the METULA unloading the cargo.

During September approximately 50,000 tons of oil were ultimately transferred to the HARVELLA and subsequently to the Norwegian tanker BERGLAND, a tanker of approximately 96,000 deadweight tons, for transport to central Chile. The METULA was subsequently refloated at 2:20 a.m. on September 25, 1974 and moved approximately ten miles west to a safer anchorage for the rest of the oil to be pumped off. Ultimately over 140,000 tons were offloaded. Thereafter, the METULA was towed for storage in Brazil and ultimately scrapped.

Deposition of Oil on the Shore

The oil which left the METULA was rapidly spread by the currents and by normal gravity spreading after release. It was reported that on August 20 some 1,000 square miles was observed to be covered with oil slick and on the two flights made by the author, slicks surfacing from the ship were

evident in both Bay Felipe and Bay East of the Narrows. The surface slicks, however, were much more evident on the flight on September 5 than they were on the initial flight over on August 28. Views of the surface slicks are evident in Figure 7 Parts A and B.

This part of the Strait of Magellan is noted for its exceptional high winds, predominantly from the west, and these winds tended to rapidly drive the oil ashore. Based on an average of 30 knot westerly winds experienced in the area, the oil could expect to travel on the surface at a speed of approximately one knot to impact the shore of Tierra del Fuego within 3 to 4 hours. There it would strand on the shore or be slowly moved along the coastline to the northeast or southwest depending on the wind direction at the time of impact. The winds during August were such that most of the oil that did not volitalize or dissolve into the water column was driven onto the north shore of the Island of Tierra del Fuego as shown as Deposit A in Figure 9. This initial deposition covered between 40 and 50 miles of coastline.

During the field operation in late August and early September, some 25 miles of this beach was walked by teams of the field party and estimates were made of the amount of mousse on the beach. The beach deposits were generally described as being between 15 to 60 meters (50 and 200 ft) wide with a depth of from 2.5 to 10 centimeters (1 to 4 in).

The location in different sectors is shown in Figure 10. Based on these crude estimates some 60,000 cubic meters of mousse was on the coastline at that time. Laboratory analysis of two collected samples led to the belief that the average water concentration of the mousse was 30 percent. This figure is lower than experienced on some later spills which show water

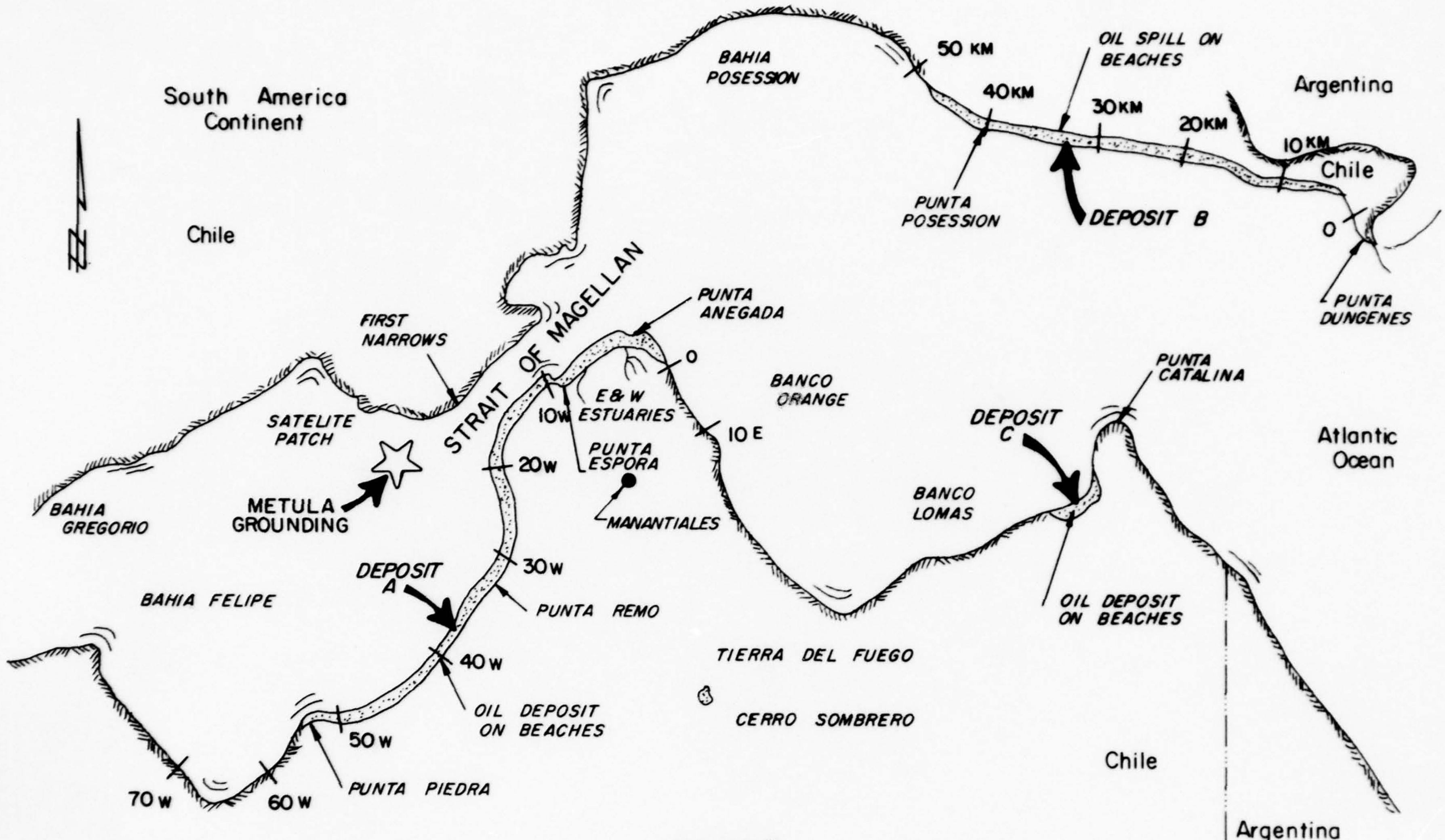


FIGURE 9

SITE OF GROUNDING AND IMPACTED BEACHES
(AUGUST– SEPT., 1974)

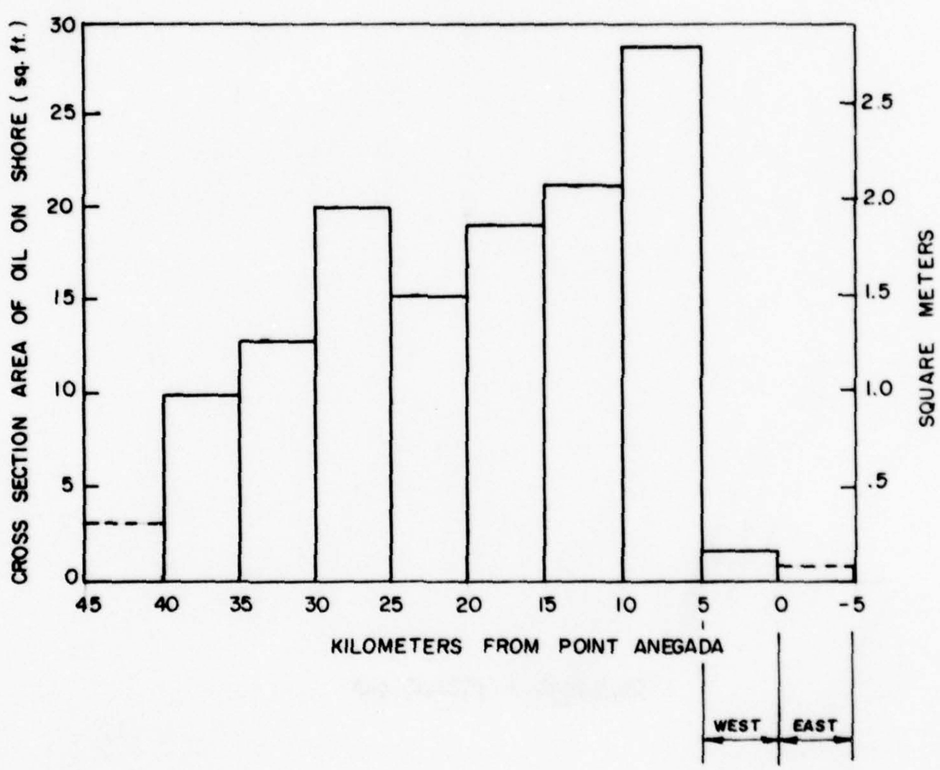


FIGURE 10

ESTIMATE OF OIL ON SHORE

Aug. 31, 1974 – Sept. 1, 1974

levels on the order of 70 percent in mousse under somewhat similar circumstances (i.e. AMOCO CADIZ and the CABO TOMAR). Even at this lower figure and assuming 40 percent evaporation of the cargo, some 56 percent of the residual oil was ashore.

The initial oil deposits appeared as two distinct layers or bands. One was a dark brown mousse, which could be described as a dark chocolate pudding, which had been deposited above the previous spring high tide mark by the strong winds. This material was mixed with sand particles, seaweed, marine worms and other materials picked up in its transport to the beach and which had been blown into the oil while on the beach. In a few cases, this darker deposit had been completely covered by the blowing sand which would dry out on the shore during the periods of low tides and high winds and then blow onto the oil deposits.

The second band consisted of a light brown mousse, very similar to milk chocolate pudding in color and texture and seemingly to behave like taffy when mixed with water in that it stayed in long, stringy bands. Both the light brown and dark brown deposits behaved quite differently from fresh oil in that it tended to stay together. It could be easily shoveled, with the depth of the oil on the shovel of about three inches deep, and when shoveled, the material had sufficient water content that it would slide loose and the shovel would stay water wet.

During Monday, September 1, a very strong southwesterly wind blew almost in direct line with the centerline of the Narrows. This caused some of the chocolate mousse material on the beaches to be blown into Bahia Posession and on the flight made on September 4, it was observed that this material had been deposited on an approximately twenty-five mile stretch of the southern shore of the continent. This location is

labeled Deposit B on Figure 9.

During the trip across the channel on September 2 and during the flight on September 4, large patches of darker oil appearing to be spreading faster than the chocolate mousse were observed on the water on the Narrows and to the east of the Narrows. It was later learned that an additional Bunker C tank had been ruptured prior to this period. When the wind shifted from the southwest to the northwest on September 3, some of the darker, fresher oil was swept to the south shore of Bahia Posession of the Narrows and pooled just south of the Point Catalina. This deposit, shown as Deposit C on Figure 9, later proved to be less significant.

During the following weeks, the mousse continued to spread, be stabilized on the beaches or to be transported to sea. During the following trip in January of 1975, the mousse was observed at more westerly locations on the shore of Bahia Felipe but was generally stabilized in the same areas as observed before. The locations of the deposits in January of 1975 are shown in Figure 11.

Information on the behavior and fate of the mousse on typical coastal components will be covered in the next section.

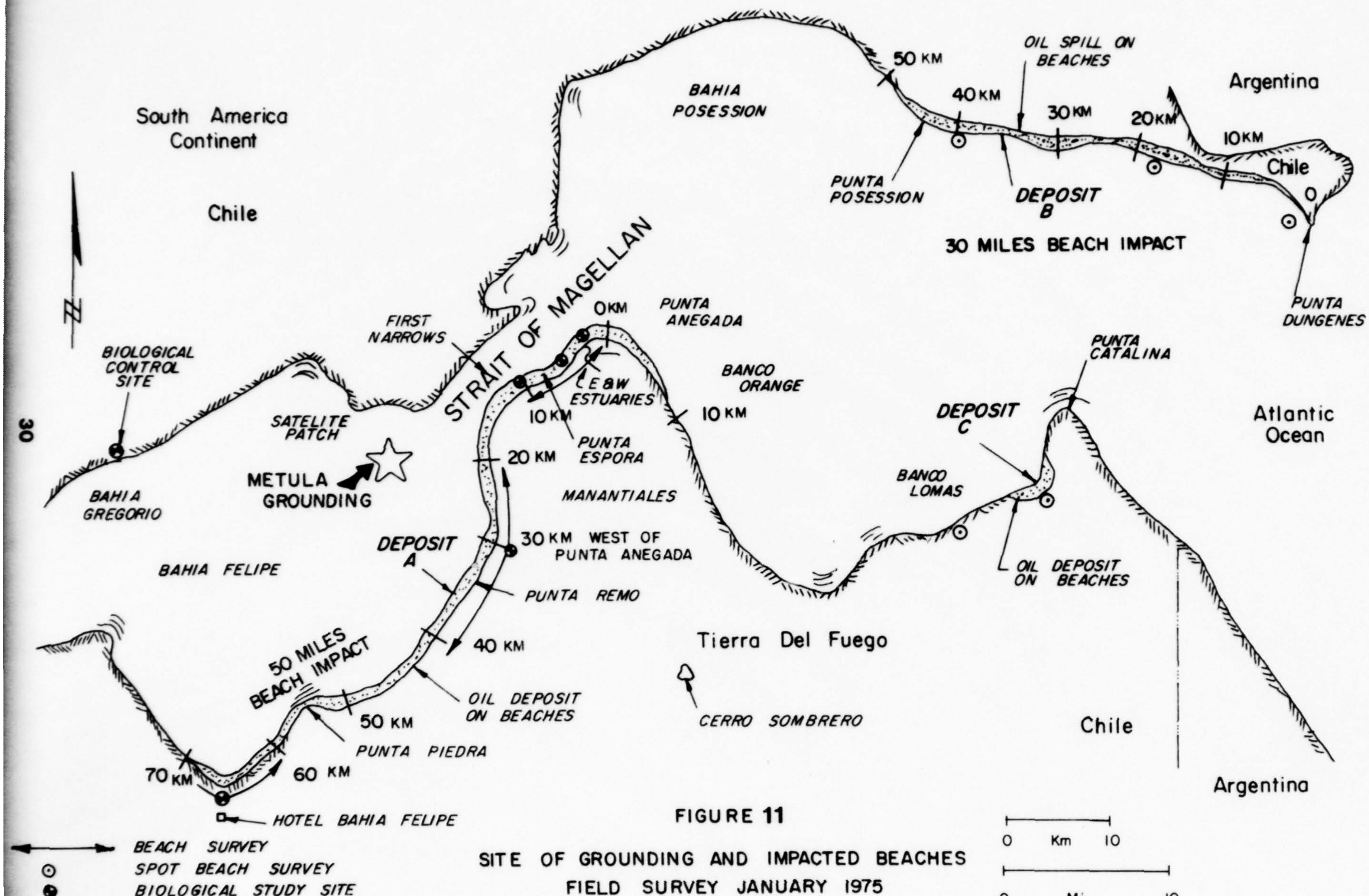


FIGURE 11

SITE OF GROUNDING AND IMPACTED BEACHES
FIELD SURVEY JANUARY 1975

SECTION III

OBSERVATIONS OF THE IMPACT OF THE METULA SPILL IN SELECTED ENVIRONMENTAL COMPONENTS

The coastal system of the Straits of Magellan that was impacted by the spill was visited by the author on six different occasions between August 1974 and January 1978. Table 2 is a listing of the specific sites visited on the various trips. In this section of the report the author describes his observations over the three and one half year period of observation after the spill at the various sites noted in Table 2.

All of the figures for this section are presented at the end of the text segment describing them. The figures all give site locations of the area being described.

Bahia Gregorio Control Site

The control site which was selected and monitored on several trips was located on the north shore of Bahia Gregorio northwest of the spill site. The system is not a pristine site in that the Bahia Gregoria Oil Shipping Terminal is located a few kilometers to the west and the San Gregorio Hacienda Buildings which generate some contamination are located about a kilometer to the east. Nonetheless, the site seems to have the typical features and flora and fauna of the area. The pictures in Figure 10 depict the area.

The beach zone typically consists of a relatively shallow upper level near the spring tide high water mark, a steeper enbankment between spring high water mark and near the spring low water mark and then a broad shallow

TABLE 2

VISITS TO METULA SPILL SITE

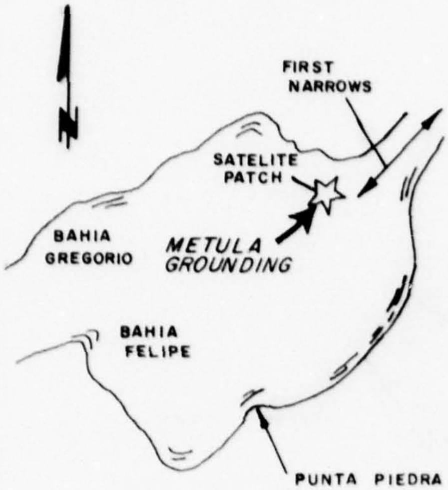
Location	Aug 1974	Jan 1975	Jan 1976	Aug 1976	Jan 1977	Jan 1978
Central Site Bahia Gregorio	x	x	x	x	x	x
Punta Delgado	x	x	x	x	x	x
Espora Flats	x	x	x	x	x	x
East Estuary	x	x	x	x	x	x
West Estuary	x	x	x	x	x	x
Punta Anegada East		x	x	x	x	x
Bahia Azul		x	x	x	x	x
Southshore Narrows	x	x	x			x
Bahia Felipe West		x	x	x	x	x
Bahia Felipe East	x	x	x	x	x	x
Bahia Felipe Cliffs	x	x	x			x
Punta Catalina		x				
Punta Posession		x				x
Punta Dungenes		x				x
Isla Magdalena		x			x	
Aerial overflights	x	x			x	

flat that was exposed only on the lowest, spring low tides. These shallow areas that are exposed during low tide are covered with rocks ranging in diameter from three to eight inches.

In the lower intertidal area algae grows in profusion, large colonies of limpets and mussels are in evidence, small crustacea are found under rocks and the sediments yield a diverse population of polycheates.

Figure 12 Parts A and D show the general area and Parts C and E show closeup of the marine community on, around and under the cobbles. The only oil found in this area has been a tar residue on occasional rocks found at the upper intertidal zone. A handfull of rocks gathered over a half-hour period is shown in Figure 12 Part B.

It has not been determined if the occasional oiled rocks in the part of the area are the result of the METULA spill or from other shipping and production sources.



PART A
8/78

PART B
1/78

PART D
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PART C
1/74

PART E
1/78

FIGURE **12**

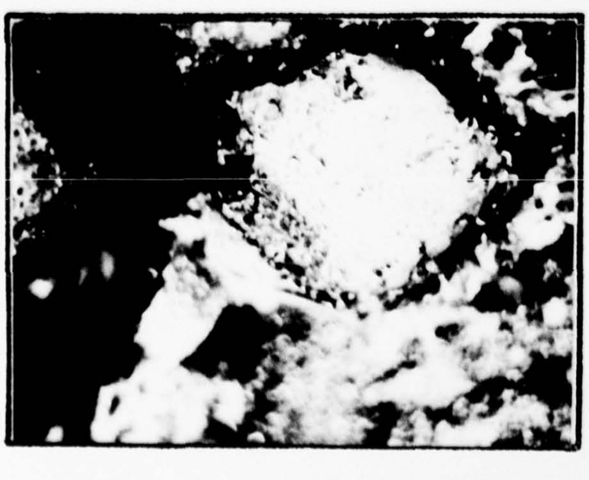
A - Typical view of uncontaminated beach showing steep sand beach, stranded detritus and near top of beach and cobble area in lower Intertidal Zone.

B - Tarred rocks found on Gregorio Beach.

C - Crustacea living under cobbles in lower Intertidal Zone.

D - Lower Intertidal community with cobbles, algae and marine life.

E - Close-up of limpets and mussels in lower Intertidal Zone.



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Hotel Bahia Felipe and Punta Piedra Area

The site located where a small creek runs into the southwest corner of Bahia Felipe some 65 km west of Punta Anegada is named the Hotel Bahia Felipe site after an old frame farmhouse which served as a small hotel at the time of the January 1975 field program. The hotel burned during the latter part of 1975 and is no longer in existence.

This site was near the westernmost extent of the significant impact of the METULA spill. The site was not visited during the time of the spill but was studied extensively in January of 1975.

At that time it was reported that the oil consisted of a surface layer approximately 1/2 centimeter (3/16 in) thick and about 3 meters (10 ft) wide. The oil had visibly penetrated the sand for approximately 3 centimeters (1 in). The top deposits were observed to decrease rapidly over a 3 kilometer (2 mi) distance to the west and increase substantially in width and thickness in the 3 kilometer distance to the east. Small patches of oil 15 to 30 centimeters (6 to 12 in) wide at the water line were found in the small estuary which enters at this point. During low tide extensive rocky intertidal zones were exposed in this area which were exceptionally rich in algae, mussels and other marine life.

At the Punta Piedra site some 8 km to the east, the band was slightly wider at the top of the beach but similar in thickness and consistency. The summer sun of the area acting on the thin dark mousse layer caused the mousse to become warm and thin and to penetrate into the surface sand. This penetration permitted the evaporation of the light ends and water and left a layer of crusty black oiled sand which has been gradually eroding away under the influence of the wind and surf.

Figure 13 shows a series of photographs for this area. Part A and Part B show the deposit at the beach top in January of 1975 and Part C shows the still soft mousse appearance of the deposit at that time. Parts D and E show the same zone two years later. In one case a stretch is shown which has been little changed in coverage whereas in the other only small patches of the oiled crust remain.

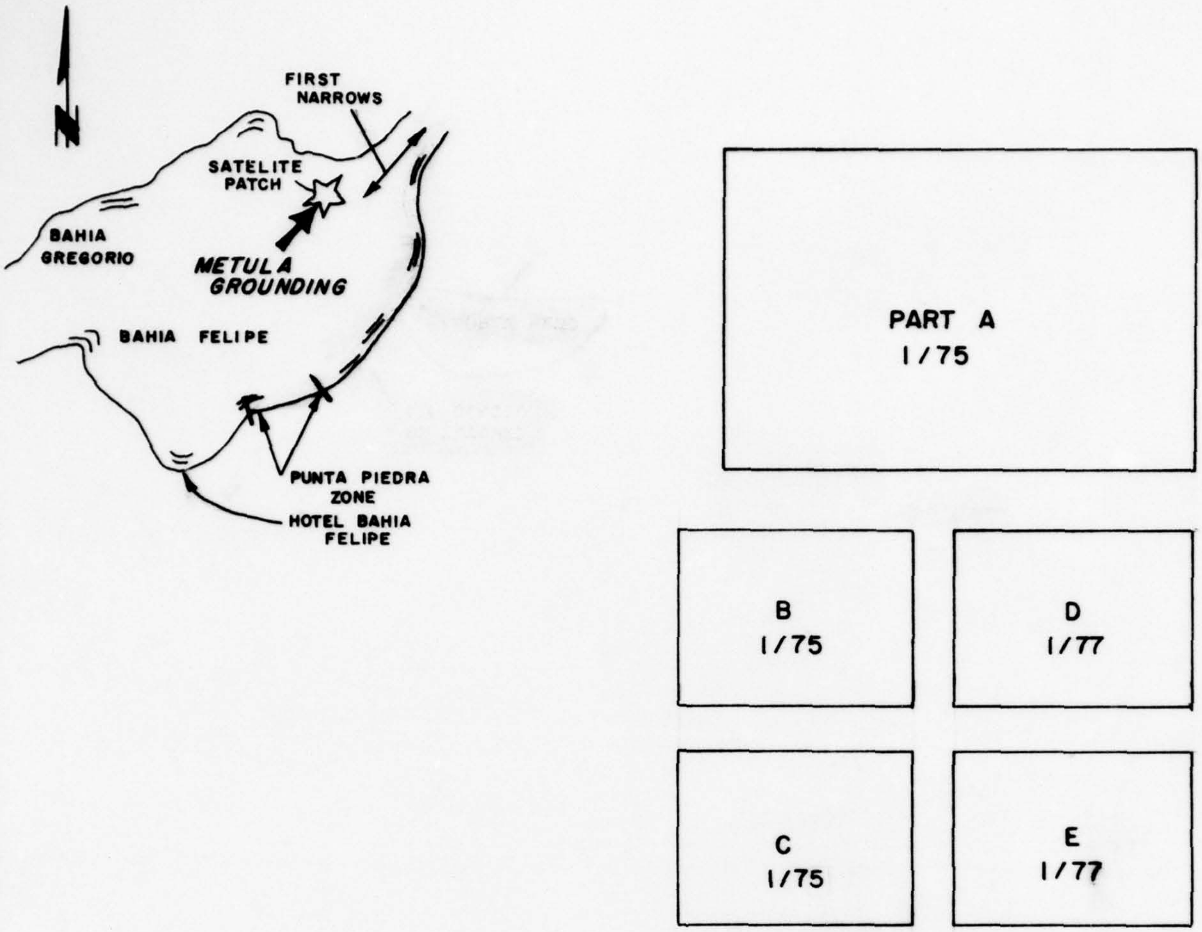


FIGURE **13**

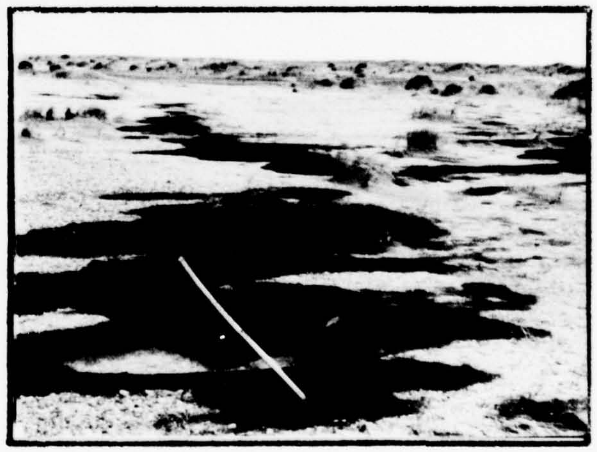
A - Deposition of oil at top of beach near Hotel Bahia Felipe.

B - Closeup of deposit at top of beach.

C - Closeup of disturbed surface showing soft mousse which has not yet penetrated into the sand.

D - Similar area near Punta Piedra two years later.

E - Area two years later where crust has been eroding away.



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Punta Remo Area

In 1974 and 1975 the beach surveys were carried out on foot from approximately 45 kilometers (28.1 mi) west of Punta Anegada (10 km east of Punta Piedra) to approximately Kilometer 21 west of Punta Anegada at Punta Baxa. The western part of this stretch of beach to Kilometer 35 is called the Punta Remo area and the eastern part from Kilometer 35 to Kilometer 25 is called the Southeast Arc area of Bahia Felipe. Punta Remo is reported differently on various maps, but is considered here as being located 38.5 km west of Punta Anegada on the Laguna Blanca (Chart 5270 of the Instituto Geographica Militar de Chile).

As shown in Table 2 approximately half of the oil that was observed on the shore at the time of the spill in August 1974 was in this area with the greatest amount in the Southeast Arc area.

At Kilometer 45 west of Punta Anegada in January of 1975 the oil deposit was observed to be about 10 meters (33 ft) wide. Approximately a 3 meter width (10 ft) was exposed at the surface with approximately one centimeter (3/8 in) of crusted mousse layer on top of from 5 to 10 centimeters (2 to 4 in) of oiled rock underneath. The remaining 7 meter width (22 ft) consisted of a 5 to 10 centimeter (2 to 4 in) layer of mousse mixed with rock and sand covered by 5 to 10 centimeters of cleaner rock and sand.

At the location 40 kilmeters (25 mi) west of Punta Anegada the deposit had increased to a total width of about 15 meters (50 ft). The layer of exposed mousse on the top of the beach line ranged from 5 to 6 meters (16 to 20 ft) wide with approximately 1 to 2 centimeters (.4 to .8 in) of

mousse on top of up to 36 centimeters (12 in) of oiled rock and sand. Another 9 to 10 meters (30 to 33 ft) consisted of clean sand with occasional oil outcroppings on top of from 15 to 30 centimeters (6 to 12 in) of mousse mixed with rock and sand.

Part of the beach between Kilometer 40 and Kilometer 35 west of Punta Anegada, had a somewhat different profile inasmuch as there was a steep slope at the back of the beach line. At the base of the slope there were some 8 meters (26 ft) of exposed mousse approximately 1½ to 3 centimeters (.6 to 1.2 in) in depth on top of some 15 to 20 centimeters (6 to 8 in) of mousse mixed with sand and rock. For the next 8 meters (26 ft) toward the beach, mousse mixed with sand was found in the beach to a thickness of up to 46 centimeters (18 in). This location was viewed at a low tide and the low water line was approximately 100 meters (328 ft) from the shoreline. Some of the rocks at the foot of the beach were oil stained. There was some loose oil around the base of the rocks and in the 15 meters (50 ft) of rock nearest shore there were patches of moussecrete up to one meter (3.3 ft) in diameter.

On Figure 14 Part A this latter stretch of beach is shown as it appeared in January of 1975. Part B shows an aerial shot of Punta Remo taken in January of 1975. The oiled stretch at the top of the beach and the large cobbled intertidal zone are evident. Part D shows a closeup of the stranded mousse in 1975. Mousse that has been warmed by the sun may be observed oozing down the beach face. Part C of Figure 14 shows the beach top area in 1978. The zone of coverage remains the same. The texture of the oil has changed in that most of the oiled layer now consists of oiled sand rather than mousse. There are, however, some areas where

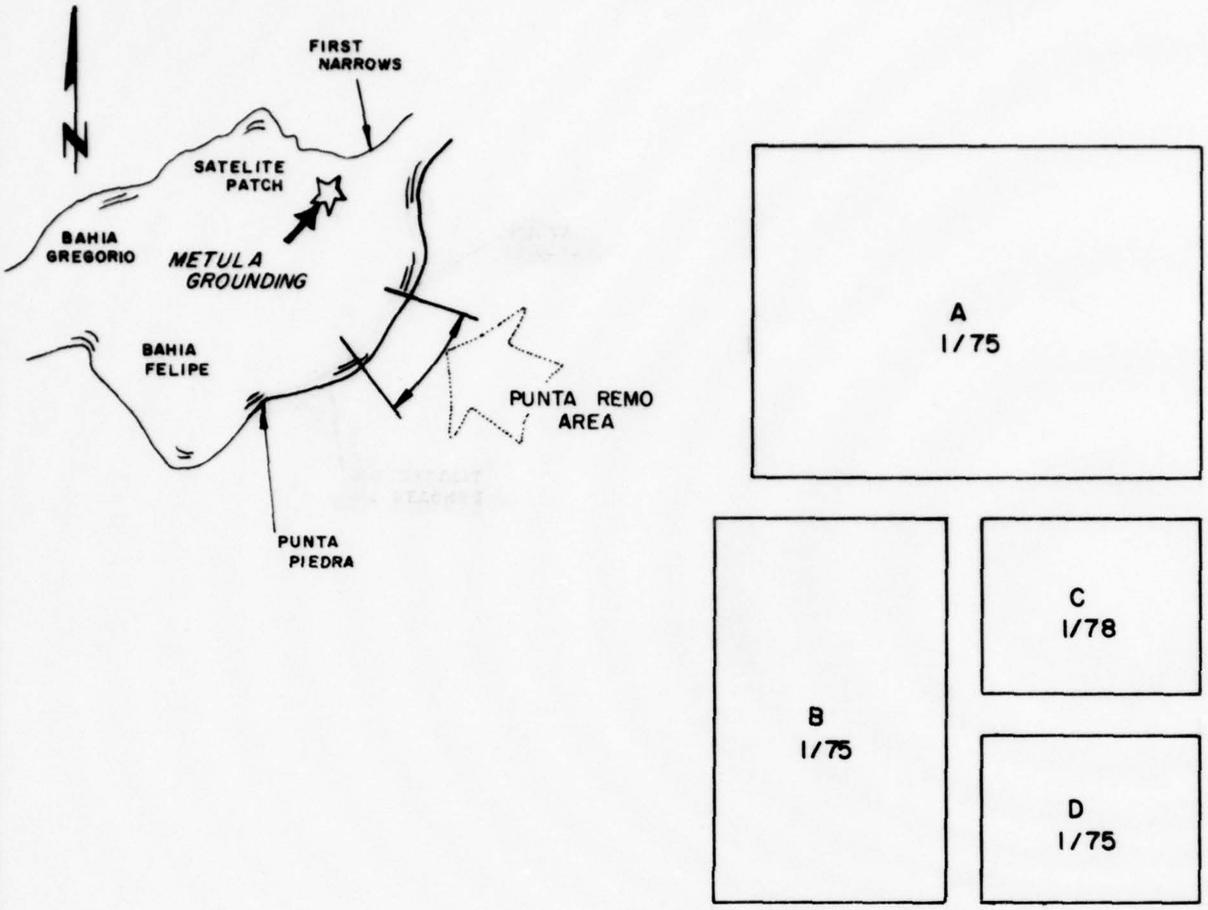


FIGURE **14**

A - Oil stranded at the top of the beach in the Punta Remo area.

B - Aerial photograph showing oiled beach top, sloping beach and wide cobbled zone exposed at low spring tides.

C - Close-up of oiled beach top near Punta Remo.

D - Oil leaching from beach top deposits under the heating effect of the summer sun.

the moussecrete layers were thick that still have soft mousse mixed with sand and gravel.

It is particularly evident from this and other beach zones that the oil or mousse at the time of the spill is deposited higher on the beach than the spring high tide turbulence area. In other words, it appears that the presence of the mousse on the surface of the water under the influence of the strong winds causes it to be deposited considerably above the high water level and thus the deposited oil erodes away slowly.

Southeast Arc Area

The Southeast Arc area of the beach served as the center of a large natural boom to collect the oil driven by the wind across Bahia Felipe. At the time of the spill in August of 1974 the oiled zone on this beach was over 30 meters (approximately 100 ft) wide. Mousse pooled against the shore at that time is shown in Figure 15 Part B.

In January of 1975 it was reported that between Kilometer 30 and Kilometer 35, the profile included a 10 meter (33 ft) wide stretch of exposed oil on the surface and another 10 meters (33 ft) of oil under the surface sand. Oil was found in this area up to 50 centimeters (20 in) below the surface.

This location was also viewed at exceptionally low tide and some 200 meters (656 ft) of rocky area were exposed. In the first 50 meters (164 ft) of area, oil was found in occasional patches up to one meter in diameter (3.3 ft) mixed with rock and sand. Very little oiling was evident in the most seaward hundred meters of rocky area.

The heaviest oiled beach on the shore of Bahia Felipe in January 1975 was located in the zone between Kilometer 25 and Kilometer 30. At that time the oiled zone was approximately 45 meters (148 ft) wide. At the top of the beach was a band of exposed mousse and debris some 15 meters (49 ft) wide ranging from a few centimeters up to 8 to 10 centimeters (3 to 4 in) deep on top of oiled sand and rock. The total depth of mousse and oiled sand and rock ranged up to 30 centimeters (12 in).

Immediately down slope was an area of cleaner sand on top underlaid with sand saturated with mousse. This zone was approximately 5 to 10 meters

(16 to 33 ft) wide. Further down slope was another 15 meter (49 ft) zone of outcropping mousse, sand and gravel layers. This layer ranged from 10 to 30 centimeters (4 to 12 in) deep. Additional, but lighter deposits were found under sand further down slope.

The wave on the beach in this zone had brown oil stained edges from resuspended oil which would leave random wavy lines in the lower zones of the beach as the tide would come in and go out. Figure 15 Part A shows a typical view of this stretch of beach in January of 1975. Figure 15 Part D shows a group of tarballs found at the base of the beach slope in January 1976.

Figure 16 Parts A through D show other views taken in this area in January 1975. These may be contrasted with those in Figure 16 Parts E through H which show the same area in January 1977 and 1978.

As time has passed the following trends have been observed:

1. Oiled detritus including kelp holdfasts at the beach top have changed little.

2. The mousse at the top of the beach has been thinned by the warm summer sun and has penetrated into the sand leaving a crusty oiled layer several inches thick.

3. Most of the oil at the top of the beach is weathering rapidly in place but there is little tendency to erode away the oiled deposit.

4. The oiled area becomes less evident as sand and fresh detritus is deposited on top of the oiled layer.

5. At the down slope edge and under some of the beach sands there remain some areas of thick soft mousse several inches thick which are weathering very slowly.

6. No oil is evident in the open beach face where it has either been eroded or deeply buried.

7. Little oil is visible in the rocks at the base of the beach face where it intersects the cobble area. It is not known, however, whether the beach slope has extended to cover some of this area.

Figure 17 shows a profile across a typical beach in this area in 1976. At this location oil and mousse was still in evidence over a zone 30 meters (100 ft) wide.

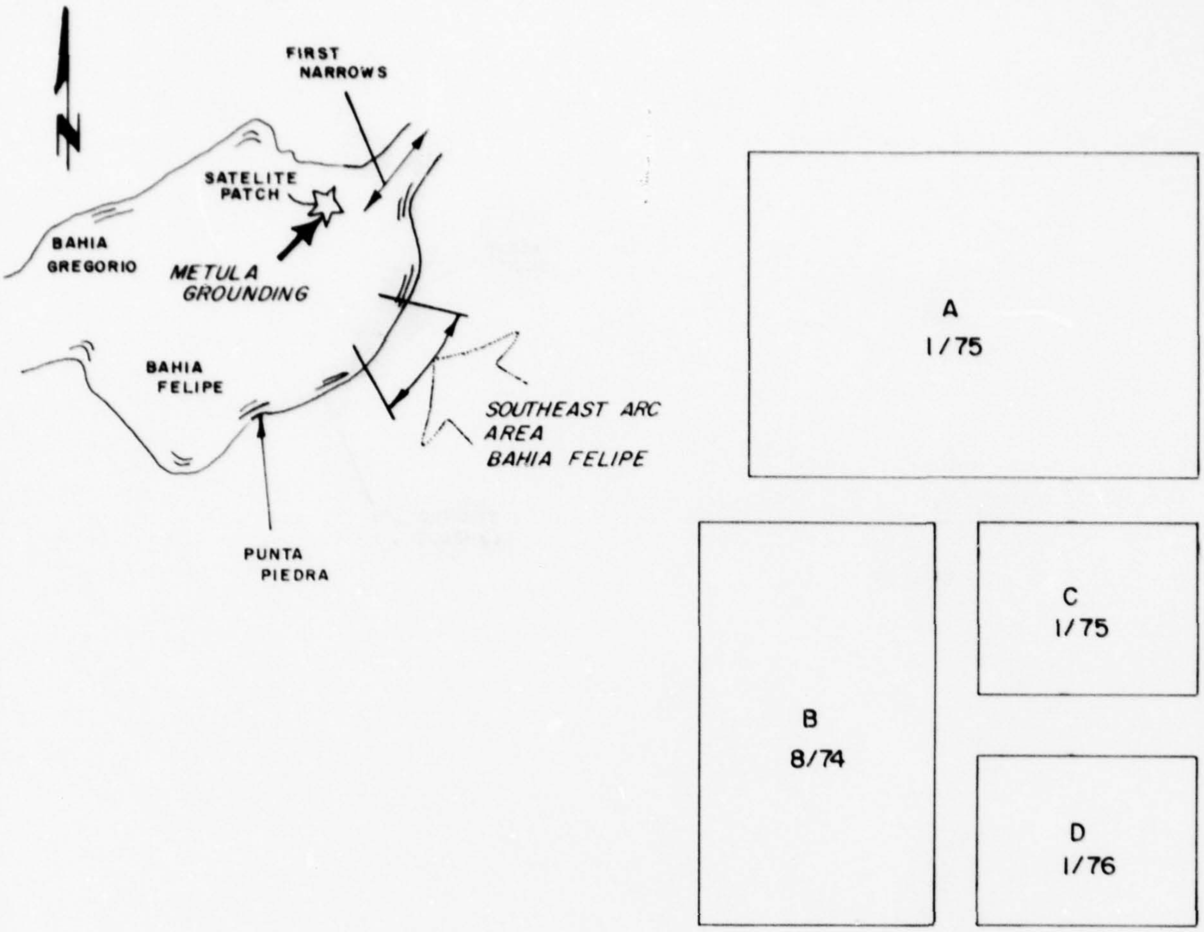


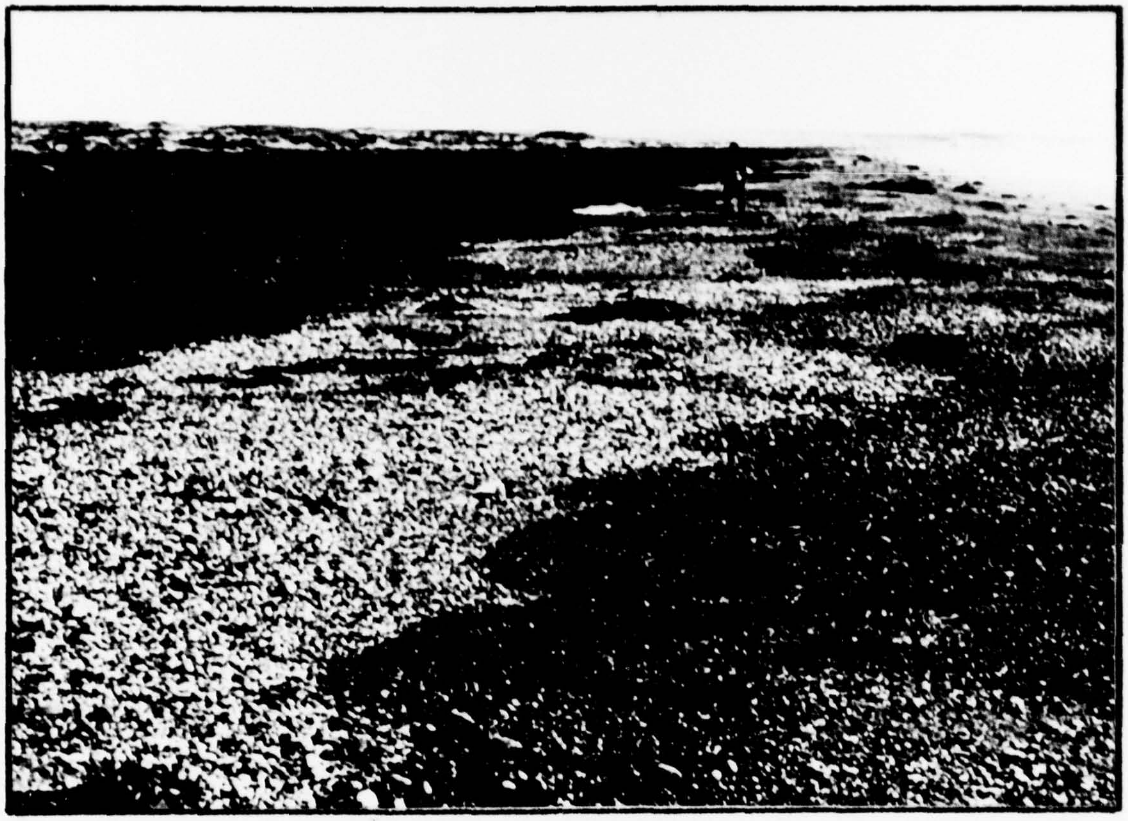
FIGURE 15

A - View of oiled beach top in maximum impact area on Bahia Felipe, exposed oil is to the left of the picture and covered oil under the sand on the right.

B - Aerial photo of southeast arc area of Bahia Felipe during the time of the spill.

C - Aerial photo of similar area five months after the start of the spill.

D - Tar balls found at the base of the beach slope.



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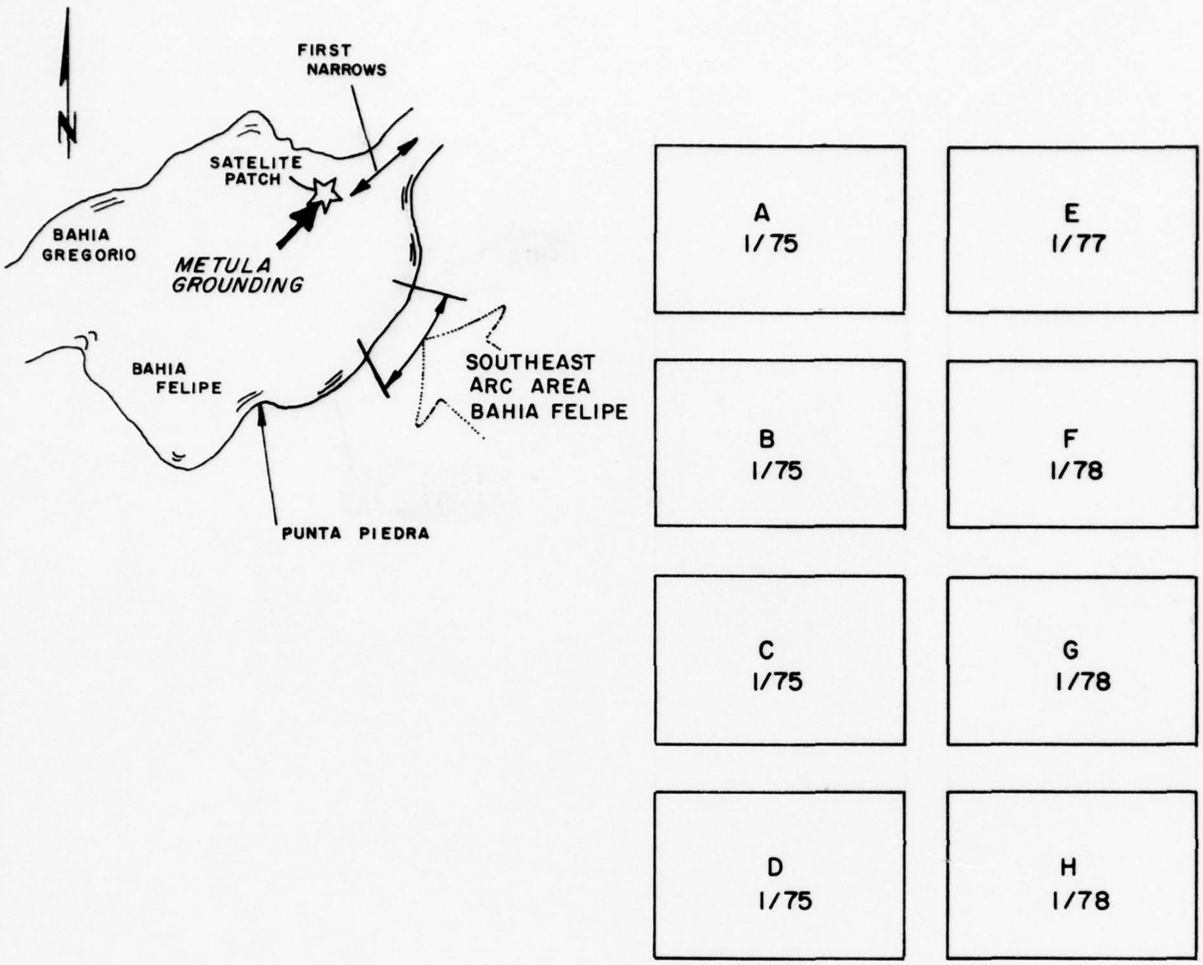


FIGURE **16**

A - Oiled beach top southeast arc.

B - Weathered oil outcropping in beach.

C - Oil outcropping in beach.

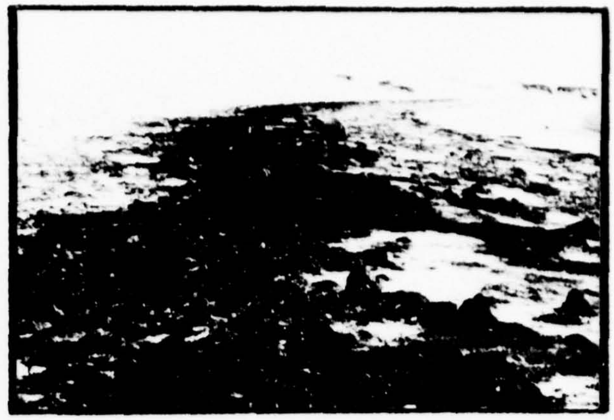
D - Close-up of oil outcropping in January 1975.

E - View of oil deposits at top of beach.

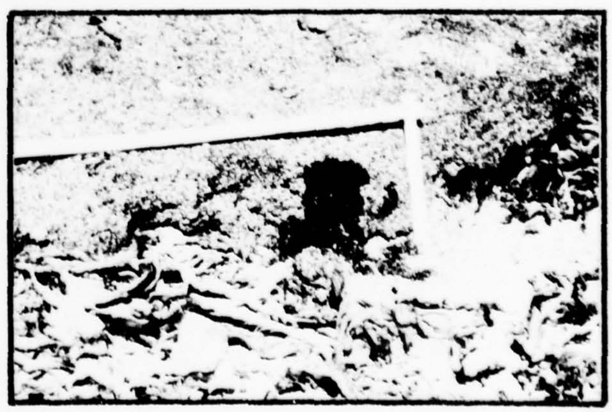
F - View of oiled outcrop 3 1/2 years after the spill.

G - Close-up of oiled outcrop after 3 1/2 years.

H - Hole through oiled layer at top of the beach.





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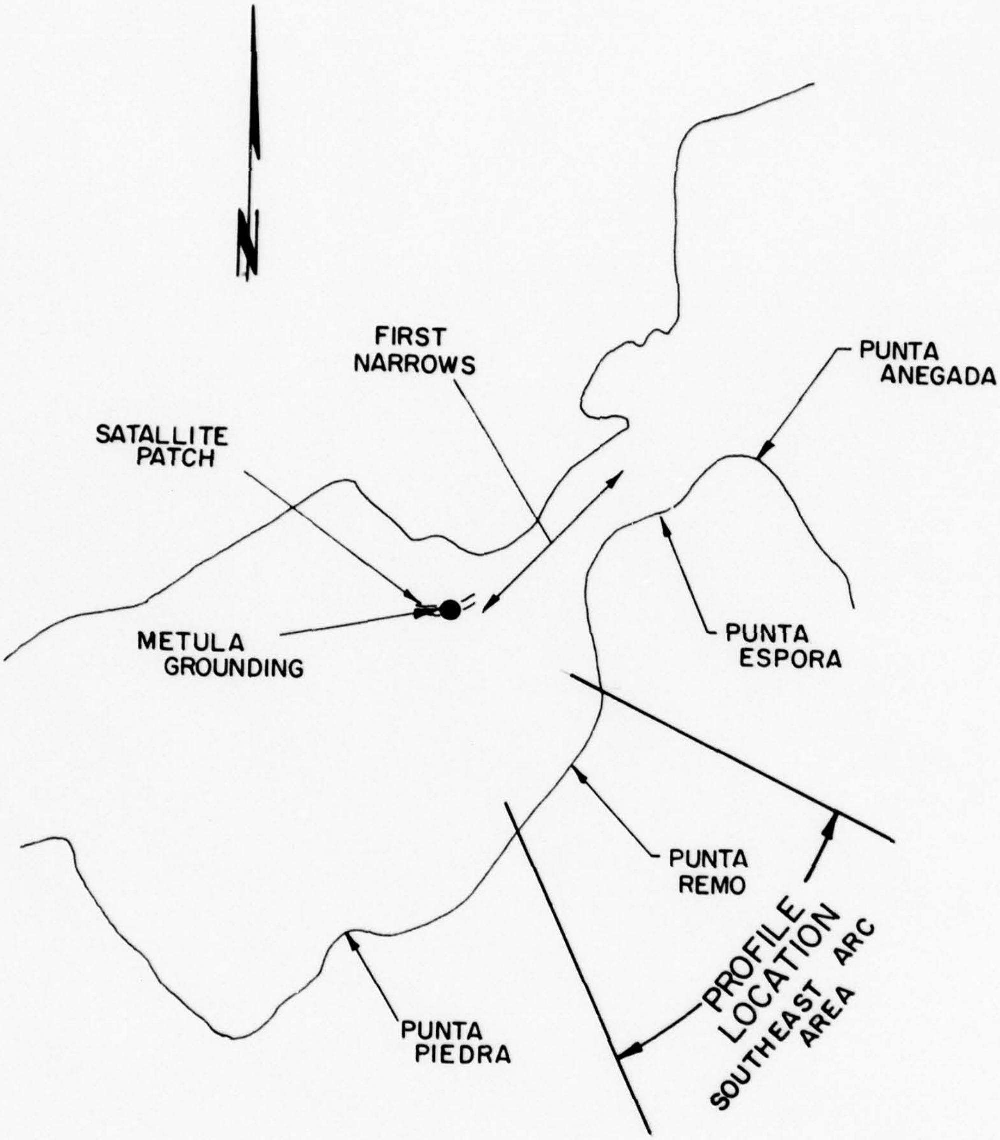


FIGURE 17

BEACH PROFILE SOUTHEAST ARC AREA BAHIA FELIPE

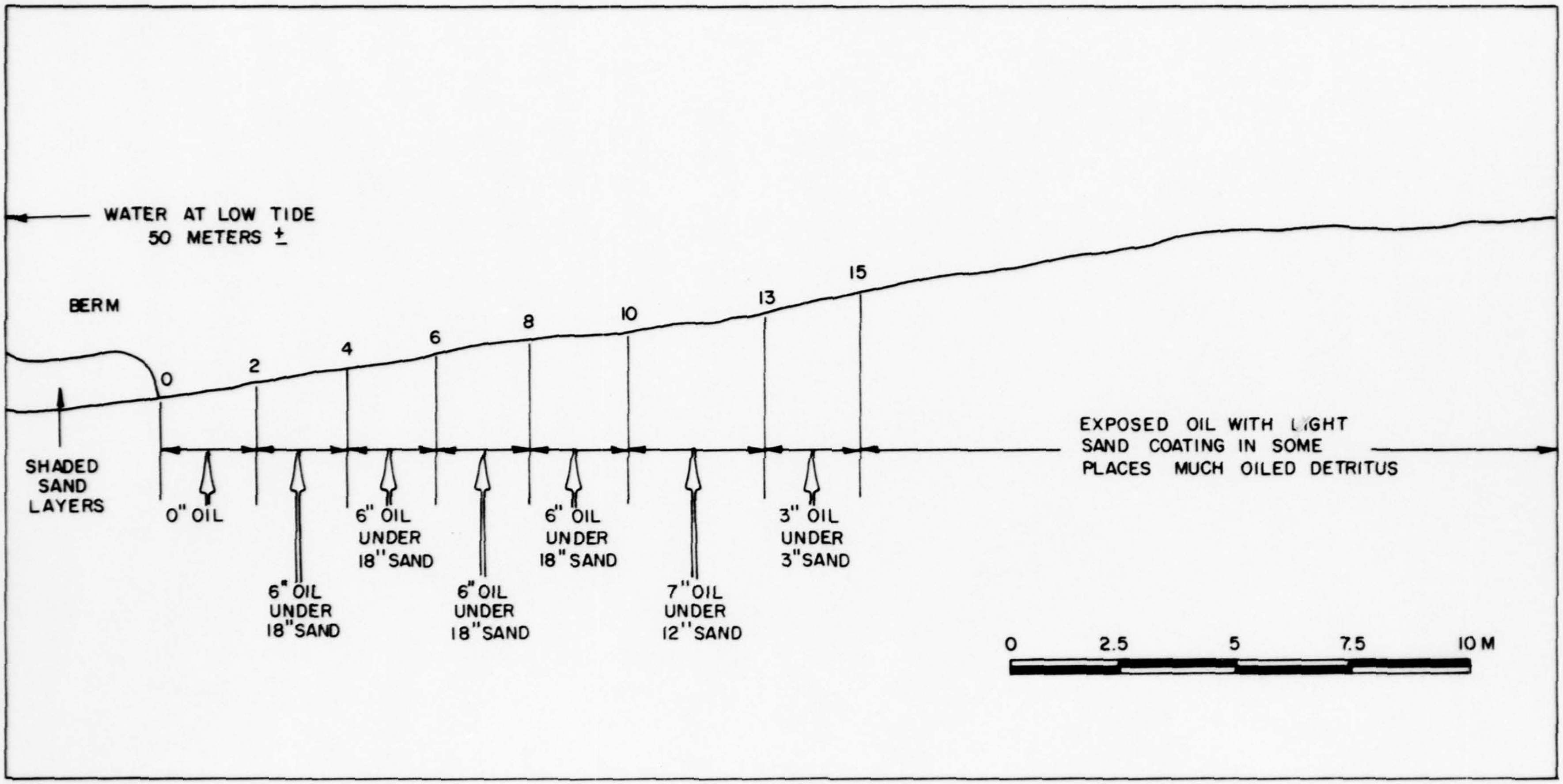


FIGURE 17

PROFILE OF SOUTHEAST CORNER OF BAHIA FELIPE

Punta Baxa Area to Punta Espora

The cliff zone which stretches south from Punta Baxa at the entrance to the Narrows to where it intersects the Southeastern Arc was also heavily oiled at the time of the spill. Figure 18 Parts B and E show aerial photographs of this zone at the time of the spill and Figure 18 Part A shows a view from a cliff top of the same general area. This area differs from the Southeast Arc in that cliffs are found at the top of the beach. This resulted in the oil being retained at a zone where future wave action could work on the deposits. At the time of the spill it was noted that the action of the surf against the base of the cliffs had in some places thrown oil on the top of cliffs 8 to 10 meters high. The deposits on the beaches at the time of the spill generally ranged from 30 to 100 meters wide (98 to 328 ft) depending on the beach slope.

In January of 1975 visual observation made from on top of the cliffs indicated an exposed layer some 10 meters (33 ft) wide and another 10 meters of sand covered moussecrete with a large number of oil outcroppings in this zone.

Figure 18 Parts C and D show cliff top views of this area in 1975. Selected points in this area have been visited in 1977 and 1978. Figure 19 Parts A, B, D, E and F show views taken in 1978.

There was still evidence in numerous places of a ledge of weathered moussecrete at the top of the beach. This indicates that wave action only occasionally reaches the base of the cliffs. This is further demonstrated in Figure 19 Part F where the oiled top of a small cave is still evident three and a half years after the spill.

Unique in this area are the large number of tar balls and tar slabs found at the base of the beach slope. These are shown in Figure 19 Parts A and B. These may have resulted from the erosion of the oiled zones at the beach top. Since the beach in this area was building at the time the question is raised as to whether there is a large amount of buried oil under the bottom of the beach slope.

From the lighthouse at Punta Baxa to Punta Espora is the exposed south shore of the Narrows. This zone was heavily oiled at the time of the spill but relatively little oil has been observed since. In January 1977 several large rocks such as the one shown in Figure 19 Part C were found to be "painted" with a 1/8 layer of tar. Oil was also found around the edges of the cobbles in the lower intertidal zone.

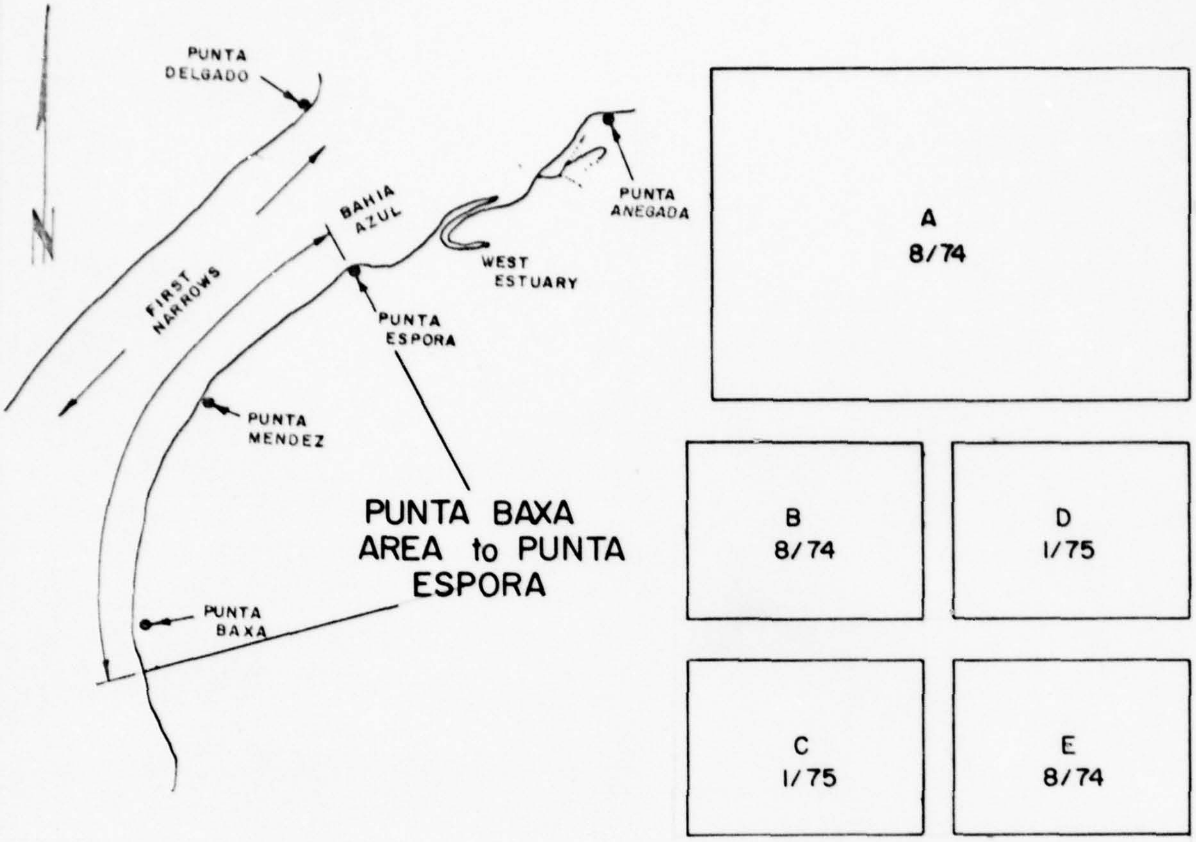


FIGURE 18

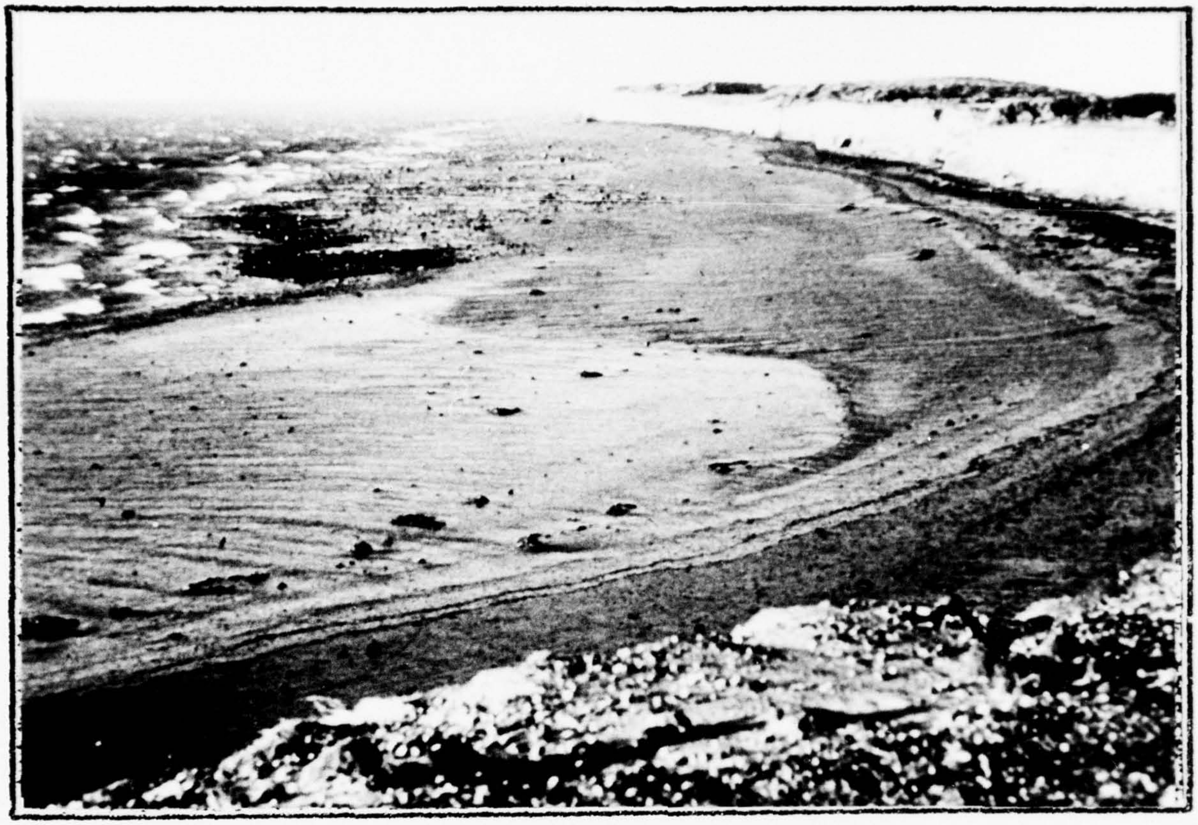
A - Oiled beach zone in Punta Baxa area during the spill period.

B - Another oiled beach zone during the spill period.

C - Same beach area observed five months later.

D - Same beach area with dead horse observed five months later.

E - Aerial photograph of Punta Baxa beach area.



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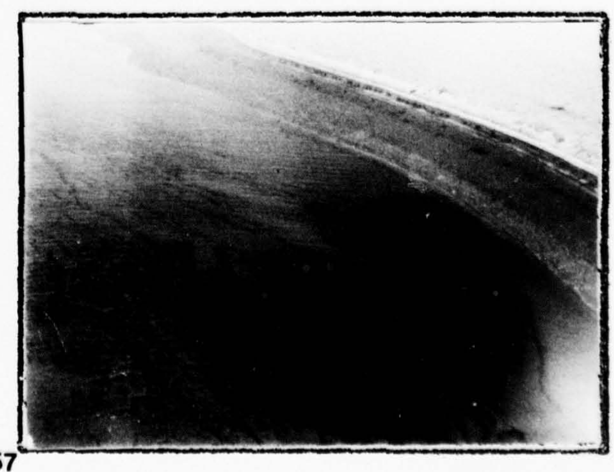


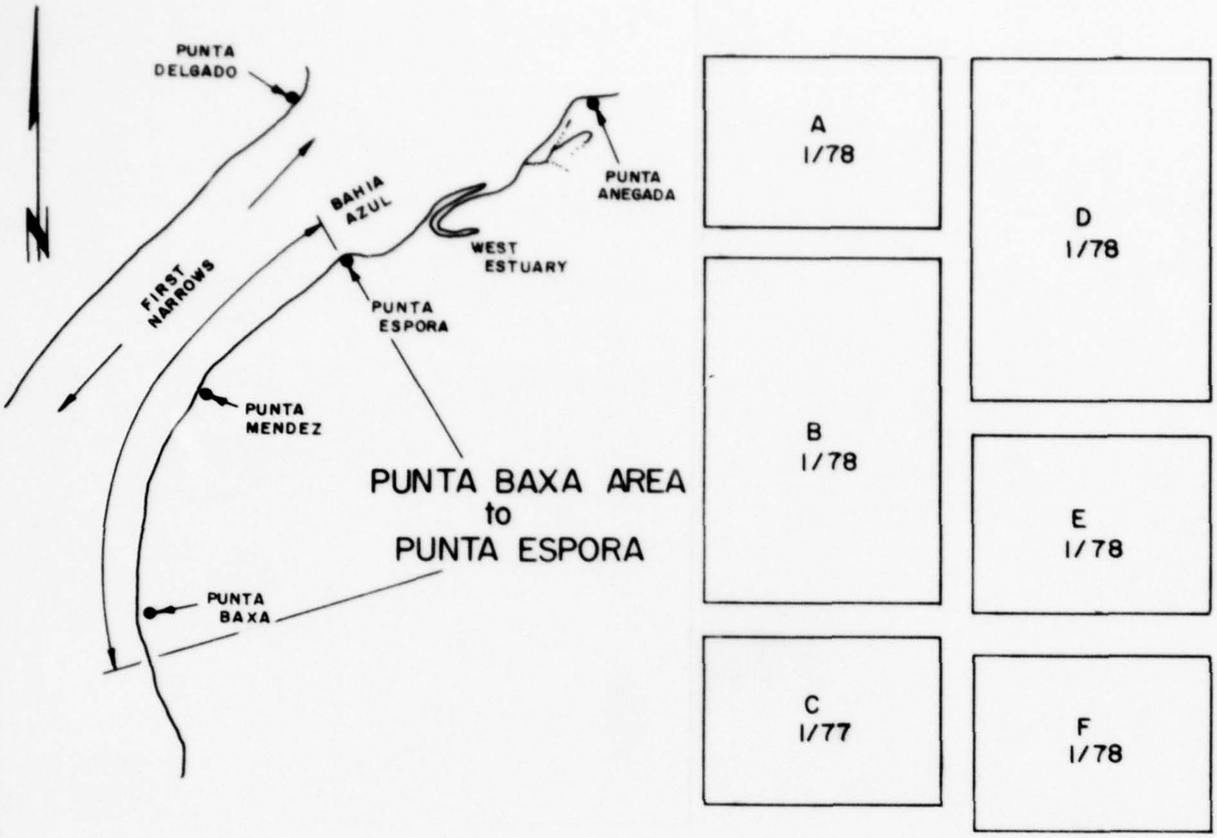


FIGURE 19

A - Tar slabs at bottom of beach face in Punta Baxa area.

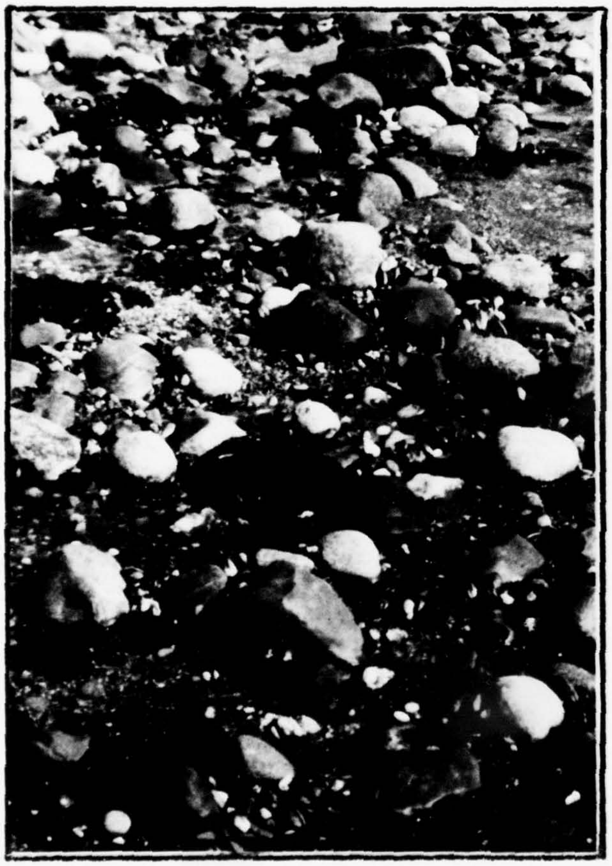
B - Tar balls at bottom of beach face in Punta Baxa area.

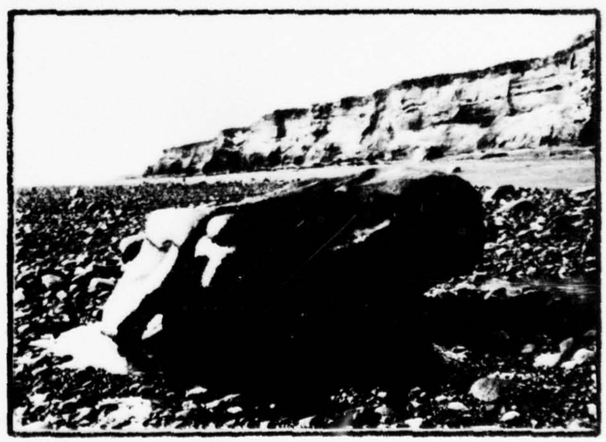
C - Tarred rock face on south shore of First Narrows.

D - Eroded oil layers at foot of cliffs in Punta Baxa area.

E - Heavy mussel population on large rock in cobble area near Punta Baxa.

F - Oil on top of small cave at top of beach near Punta Baxa.



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Bahia Azul

The Bahia Azul Beach runs from Punta Espora to the entrance of the West Estuary. It is the western part of the relatively protected "Espora" area which was heavily impacted by the spill. This overall "Espora" area is shown in the aerial photograph of Figure 20. Figure 21 Part A shows an aerial photograph of much of the Bahia Azul Beach.

The Bahia Azul Beach was not observed at the time of the spill but the construction of the new ferry landing and access road in late 1974 made observation possible in January of 1975. Figure 21 Part B shows the Azul Beach at the new ferry landing. The clean undersides of rocks disturbed by the construction contrasted drastically with the oiled beach face in the foreground and background.

The beach zone in this area is a beautiful sweeping arc with an intertidal zone of approximately 80 to 100 meters (262 to 328 ft) wide exposed at low tide. The beach has a relatively constant slope and the bottom two thirds is heavily cobbled. The bottom half is very heavily populated with marine life.

The entire beach zone in this area is heavily oiled. Figure 22 Parts A through F shows views of this beach in 1975 and 1978. Figure 23 shows a beach profile made in 1975. Almost an identical profile was observed in 1978 except for the relative absence of oil in the sandy zone between the oiled layer at the top (Figure 22 Parts C and F) and the paved cobble area shown in Figure 22 Parts A, B, D and E.

At times on the beach flat cobbles tend to build up on this beach and hide the paved areas while at other time the cobble are removed down

to the paved zone. The sheltered nature of this beach has generally protected the pavement and erosion has been slight.

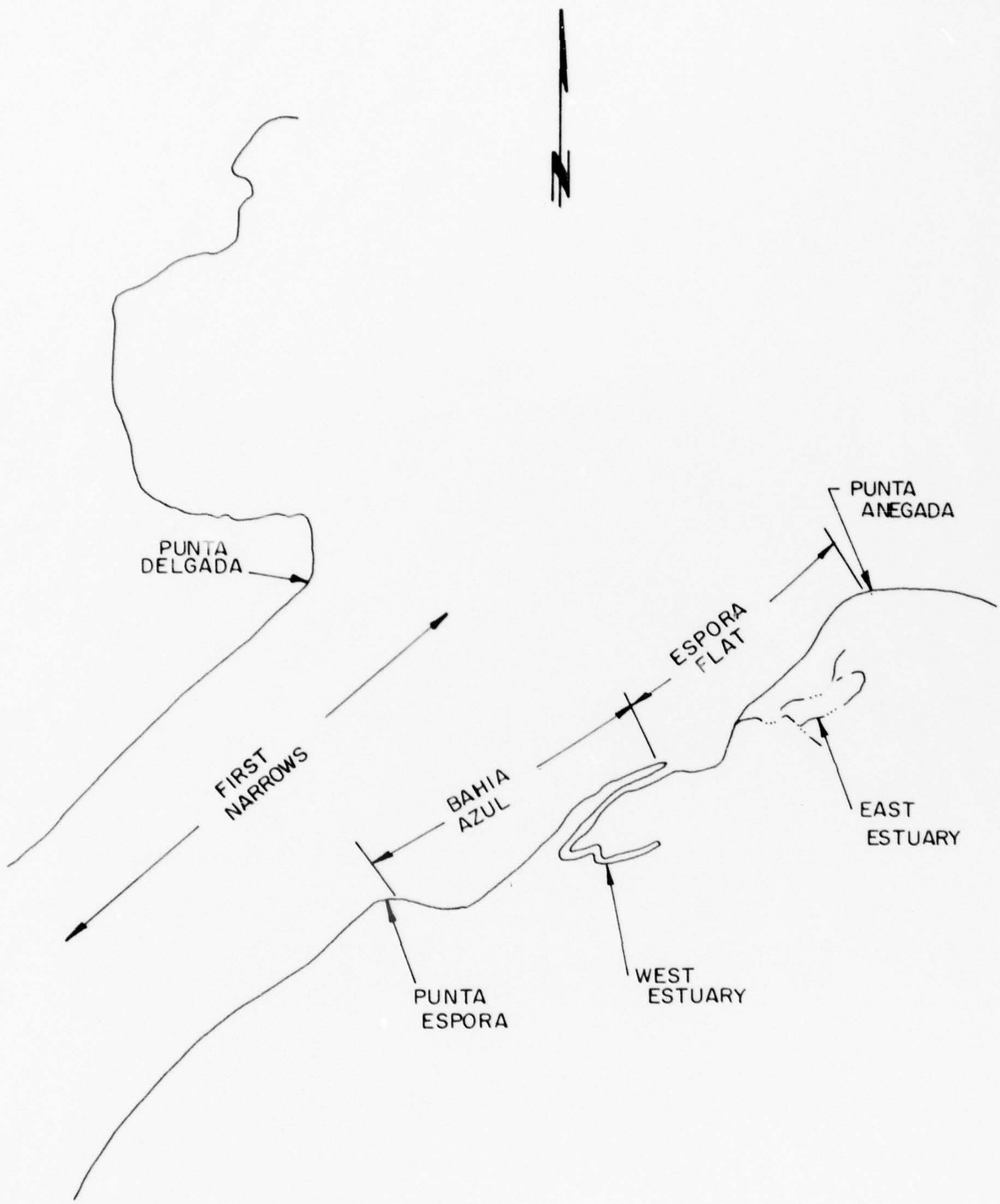


FIGURE 20

AERIAL VIEW OF SOUTH SHORE OF NARROWS EAST OF PUNTA ESPORA


BAHIA AZUL
WEST ESTUARY
ESPORA FLAT
EAST ESTUARY

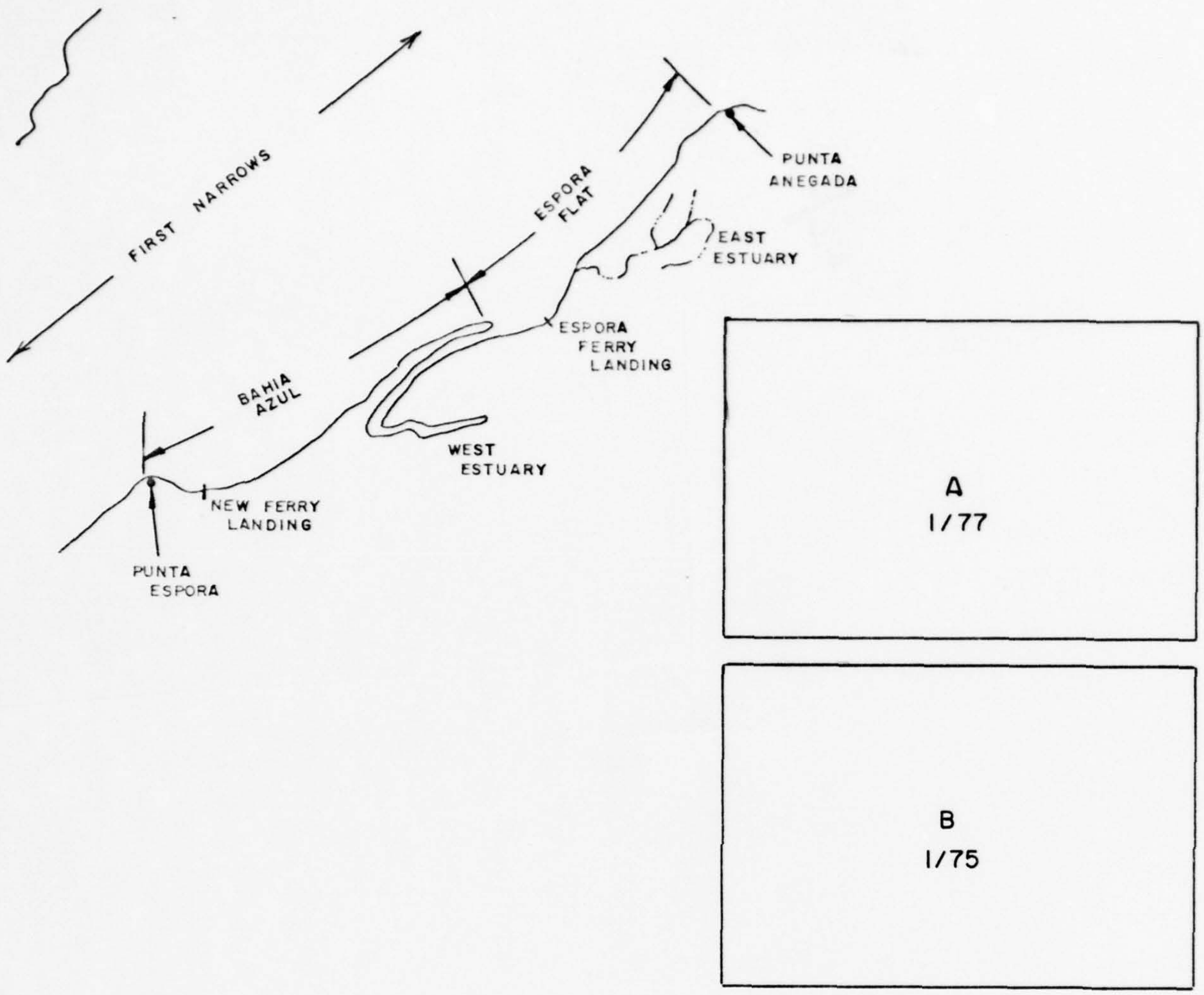
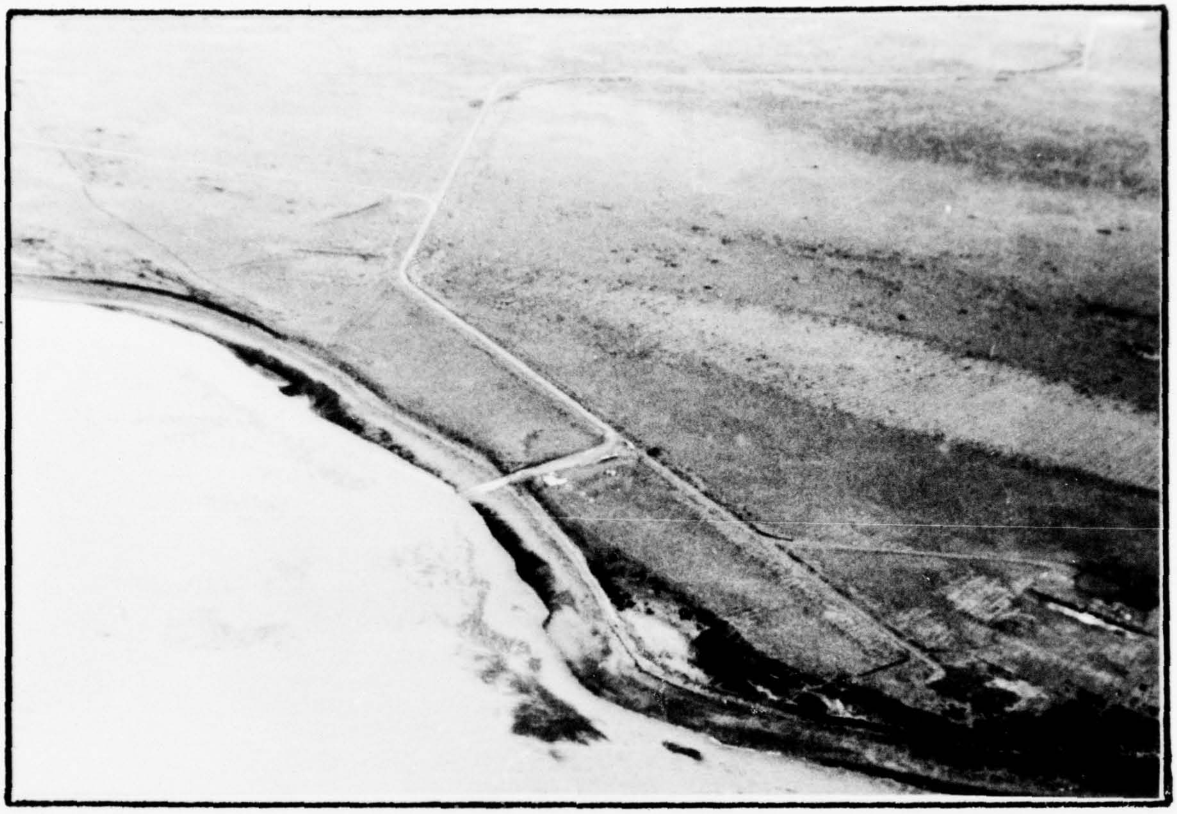


FIGURE 21

A - View of Bahia Azul Beach showing new road and ferry loading. Punta Espora is in the lower lefthand corner.

B - View of oiled beach face on Bahia Azul. New construction has turned over rocks in piling area in contrast to oiled rocks in foreground and background.



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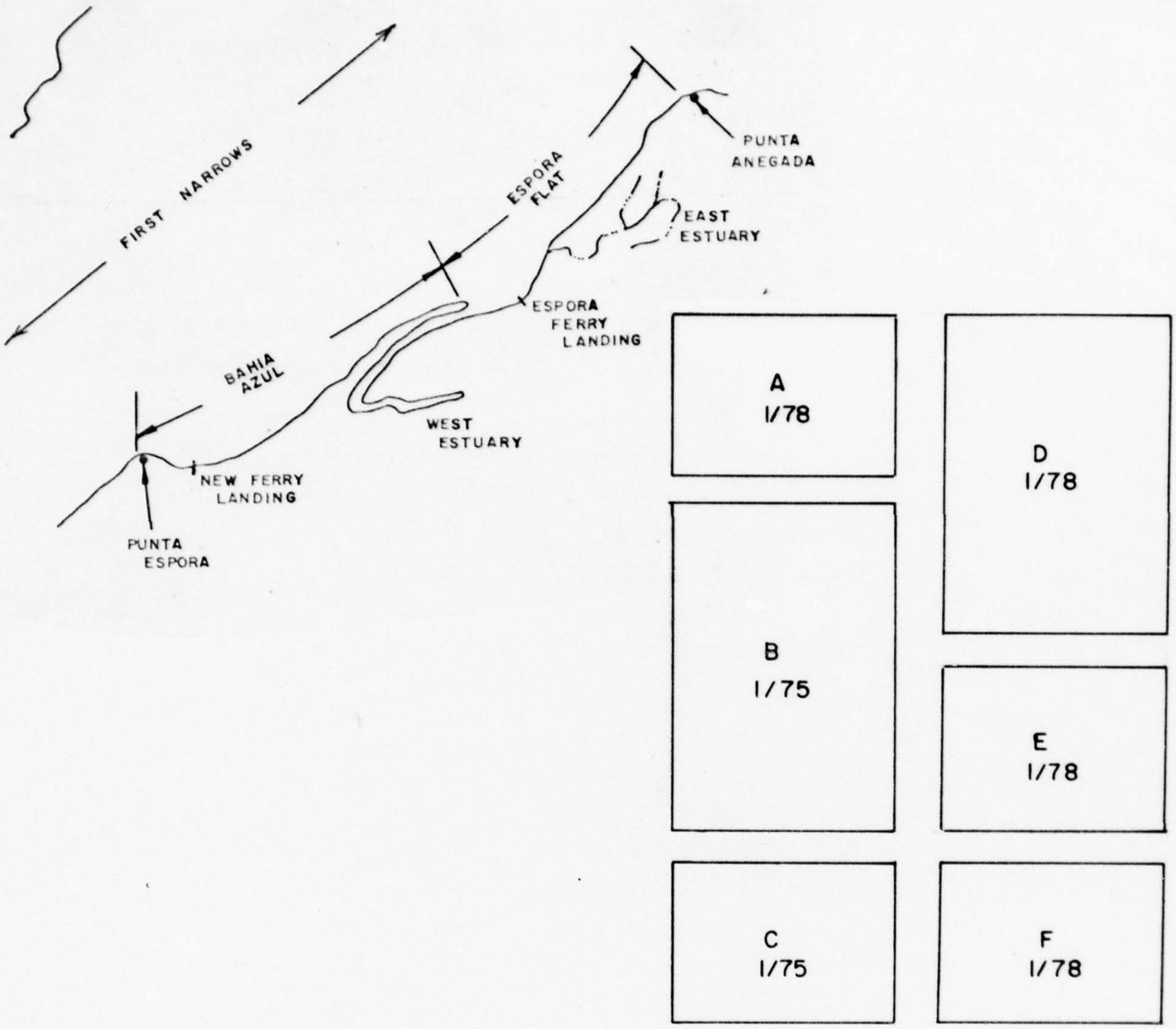


FIGURE 22

A - Paved beach to south of New Ferry landing on Bahia Azul.

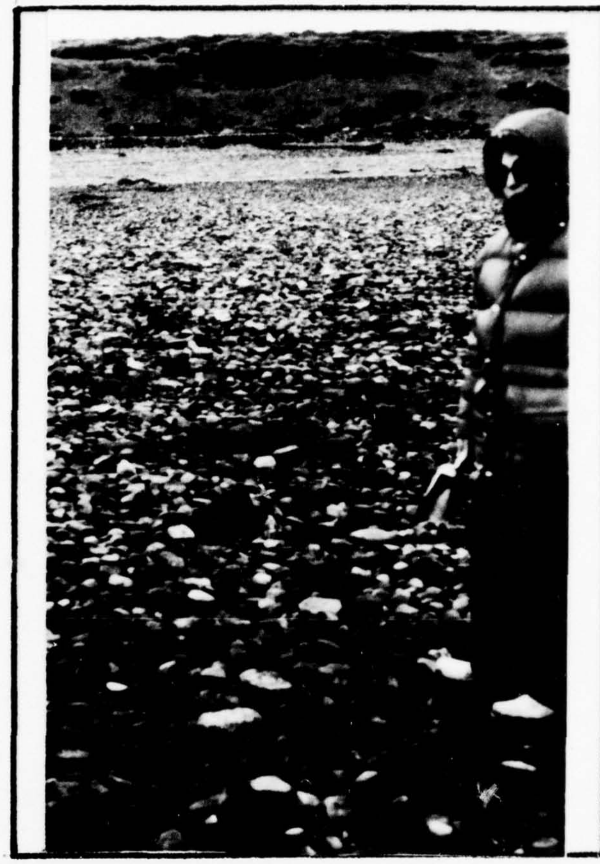
B - Closeup of oiled pavement on Bahia Azul Beach.

C - Oiled shell and flat stone beach top deposit in January 1975.

D - Series of sampling pits perpendicular to the beach on Bahia Azul shore.

E - Closeup of oiled pavement.

F - Oiled shell and flat stone beach top deposit in January of 1978.



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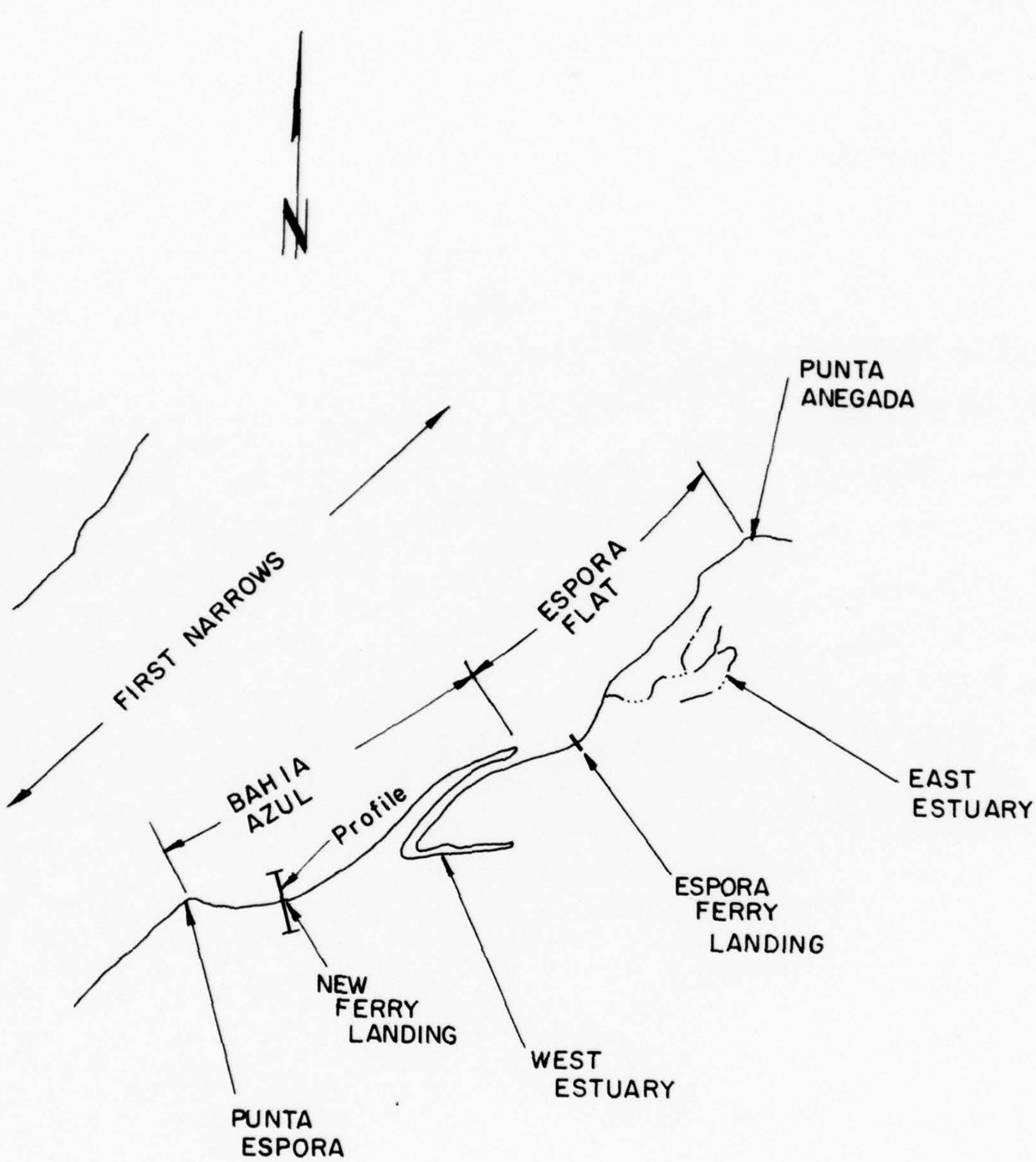


FIGURE 23

BEACH PROFILE BAHIA AZUL BEACH FACE

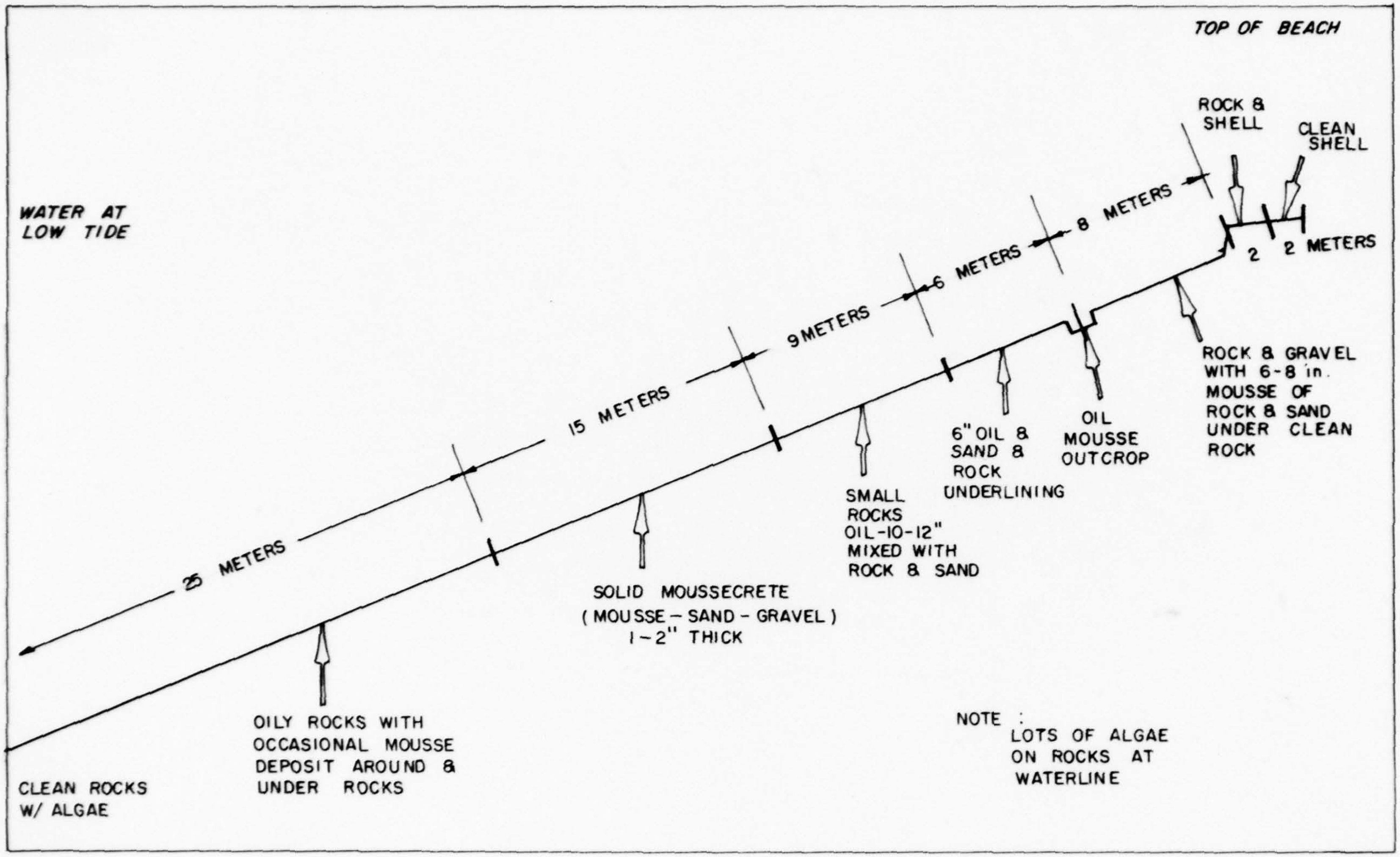


FIGURE 23

NEW FERRY LANDING AT PUNTA ESPORA

Espora Flat

The most fascinating area of the METULA spill is the intertidal area at Puerto Espora and the two estuaries that enter the Narrows in that area. The old ferry landing at Puerto Espora is located about 4 kilometers (2.5 mi) west of Punta Anegada. This area is sheltered from the predominantly northwest wind by the headland at Punta Espora and the small peninsula which protects the entrance to the West Estuary approximately 6 kilometers west of Punta Anegada. A second estuary (the one labeled "East Estuary") enters the Narrows approximately 2.5 kilometers (1.55 mi) west of Punta Anegada.

This sheltering caused much of the oil being transferred along the south shore of the Narrows to slow down its movement and become attached to the beach zone, the broad intertidal zone and in the two estuaries.

Pictures of the tidal flats in this area taken in September 1974 had shown oil at the high tide zone and only a light coating of mousse on the rocks of the tidal flats in some areas. The pooling of considerable oil in this area following the strong southwest wind of September 2, 1974 was noted and photographed during the initial field study.

The study in January 1975 indicated substantially heavier deposits in the intertidal zone than in September 1974. The initial loading of the Espora beach top in late August and early September 1974 as compared to how it looked in January of 1978 is depicted in Figure 24. In Figure 24 Parts A, B, C and D the loading on the beach at both high and low tide may be noted.

By 1978 most of the oil at the top of the beach was weathering and had become slabs of crusted sand which were being eroded or covered with

clean sand. In some lower areas, however, outcroppings of moussecrete were still evident and the mousse was still soft and pliable.

It is in the broad flat intertidal zone that the oiling at Espora was so dramatic. The sequence of events that led to this phenomenon are shown in Figure 25 Parts A, B and C.

The initial view shows the intertidal zone with limited oil in late August 1974. Part B shows mousse moved from the shore of the Narrows around the Bahia Azul into the Espora Flat area on September 2, 1974 and Part C shows the mousse deposited on the intertidal zone on the evening of September 2.

It is believed that the rapid return of the tide in this area created a hydrostatic head over the stranded oil which forced it into the sediment before it could float or be washed to the surface. Much of the flat had mousse penetrating into the sediments from 5 to 10 centimeters (2 to 4 in) and in places it was over 30 centimeters (12 in) thick. Figure 25 Part E shows a measurement pit in the pavement in 1975 and Figure 25 Part F shows a similar pit in 1978. Since the sediments are covered with cold water much of the time and since the thick mousse contains much water, the oil in the pavements has weathered very little. The new pits yield the same brown mousse observed three years earlier. Figure 25 Parts G and H show additional views taken in 1978. In Part G the algal growth on the oiled sediments may be noted.

The dramatic aerial extent of the deposits may be noted in Figure 26 Part A and the depth of the pavement-like moussecrete may be noted in Figures 26 Parts B, C, D and E. These latter pictures were taken in 1977 and 1978 where the edges of the pavements are eroding.

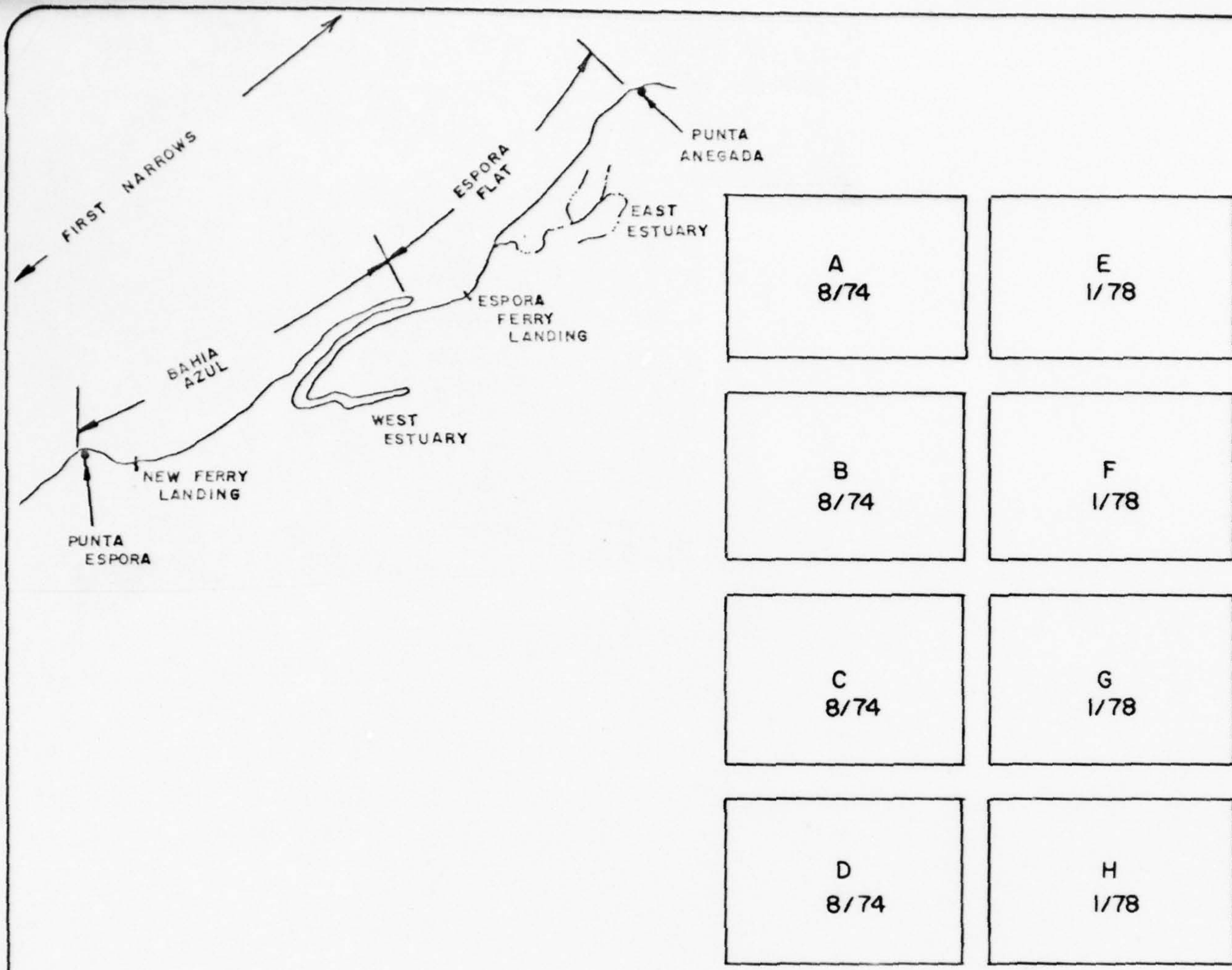


FIGURE 24

A - Espora beach top at time of the spill.

B - Old Ferry Landing at Puerto Espora at low tide during the spill.

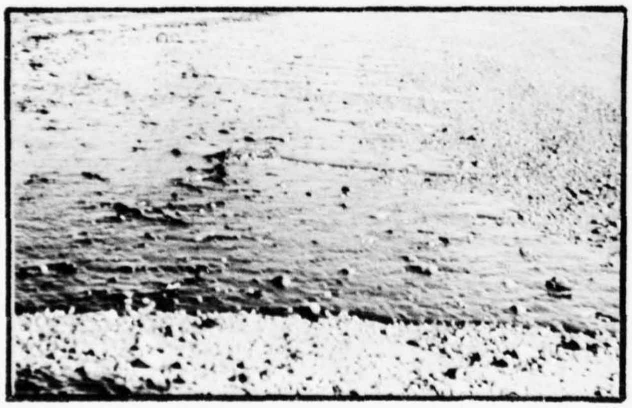
C - Stranded oil draining down beach face during time of the spill.

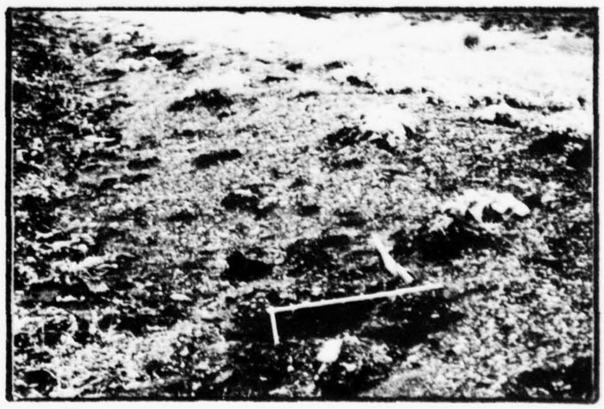
D - Ferry Unloading on oiled Espora beach.

E - Weathered oiled beach top looking west at Espora in January 1978.

F - Weathered oiled beach top looking east at Espora in January 1978.

G, H - Close-up of weathered sediments at top of Espora beach.





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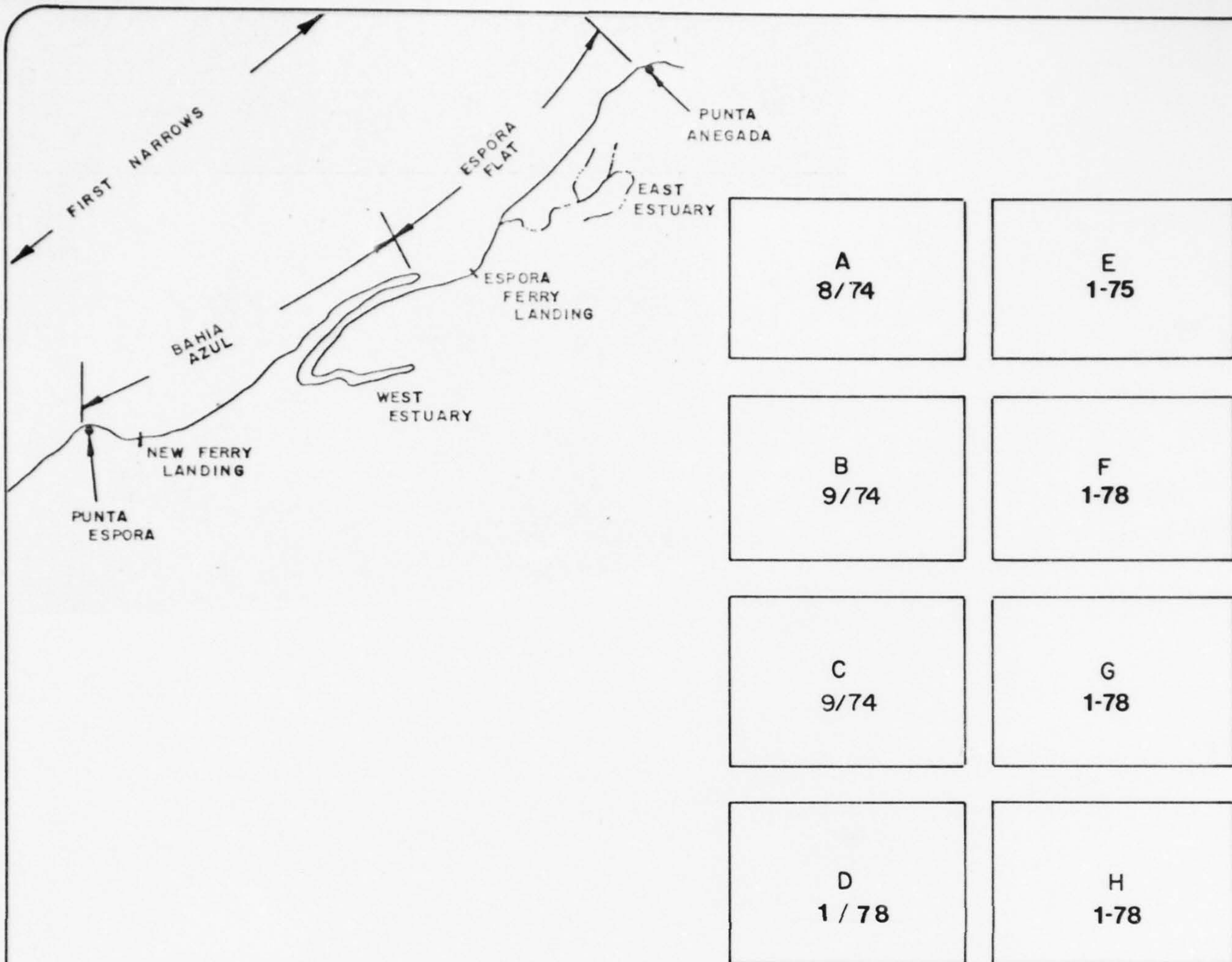


FIGURE 25

A - Espora flat in late August 1974.

B - Movement of oil into Espora area on September 2, 1974.

C - Deposited oil in Espora Flat at low tide on September 2, 1974.

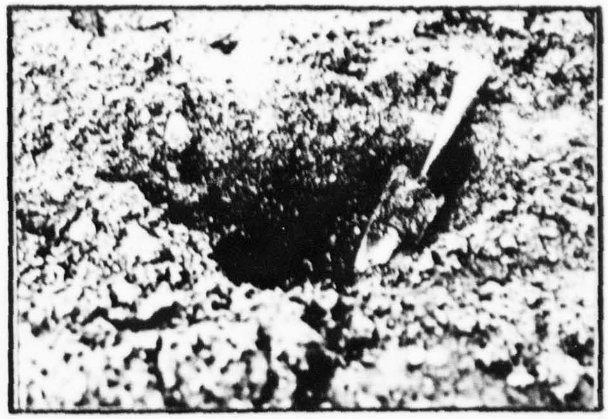
D - Algae on oil surface and mousse under surface.

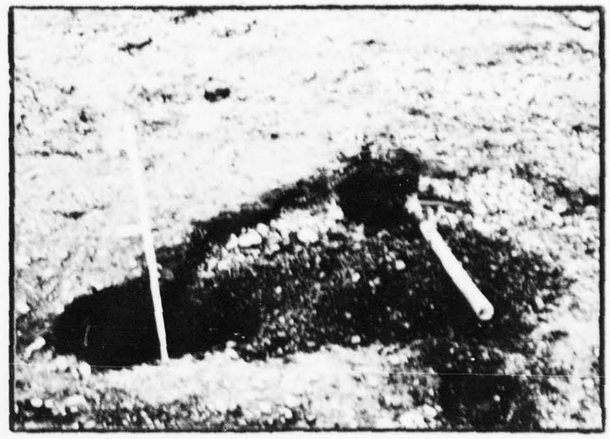
E - Oiled sediment in Espora Flat on January 1975.

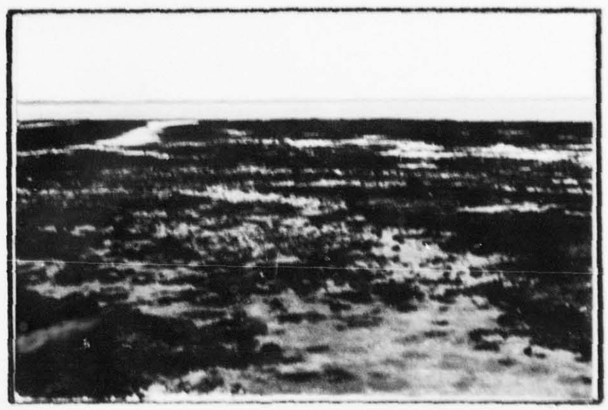
F - Oiled sediment in Espora Flat in January 1978.

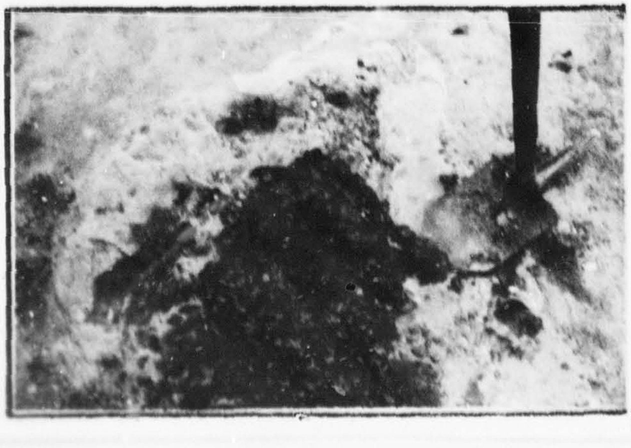
G - Oiled Espora tidal flat looking seaward.

H - Close-up of algae growing on oiled sediment.









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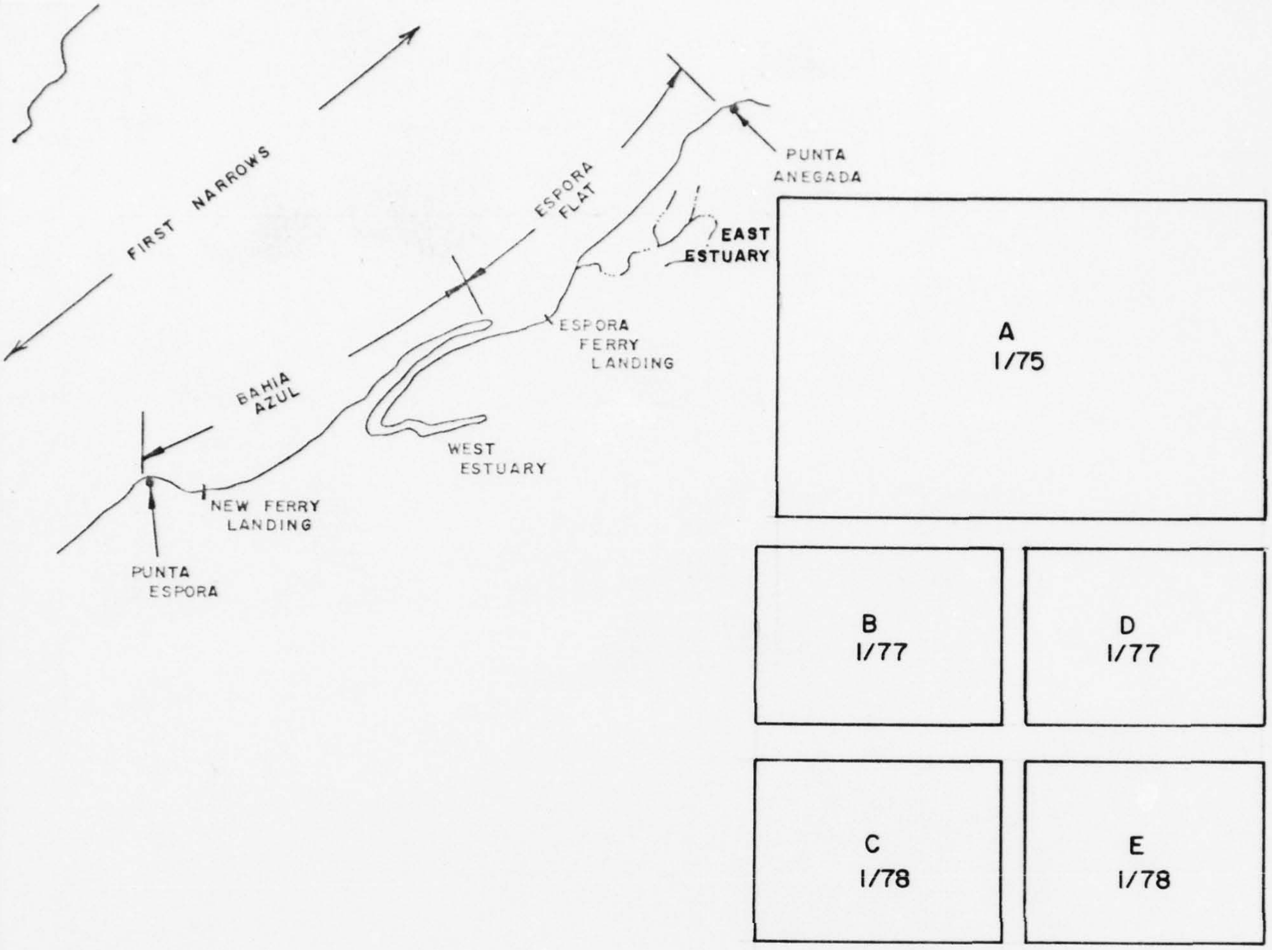


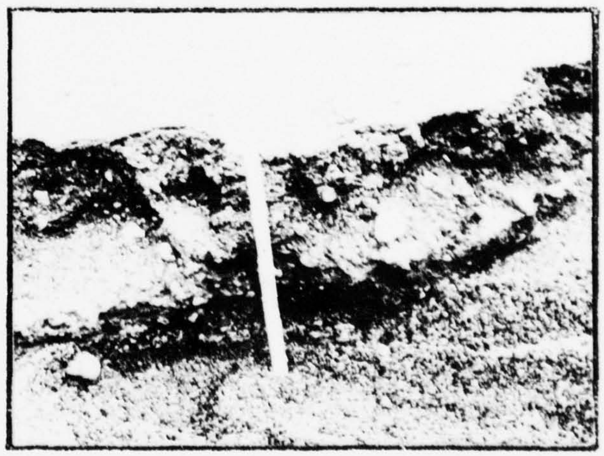
FIGURE 26

A - View along oiled tidal flat toward Old Ferry landing.

B - Eroded edge of sediment at bottom of beach slope.

C - Close-up of eroded edge showing 11 inch thickness.

D
E - Additional close-up of eroded edge taken in January of 1978.



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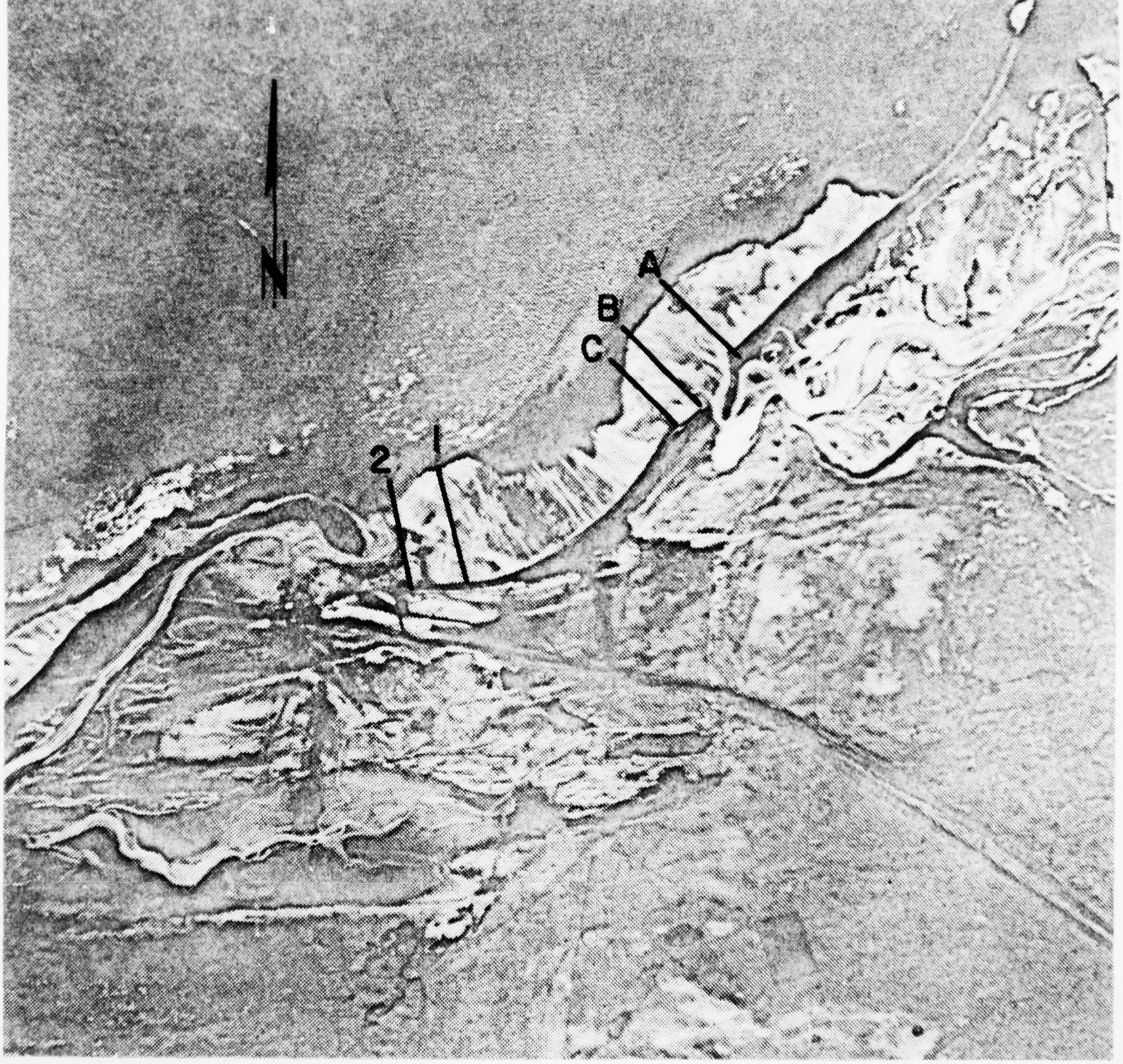


FIGURE 27

BEACH PROFILE ESPORA FLAT NEAR ENTRANCE OF WEST ESTUARY

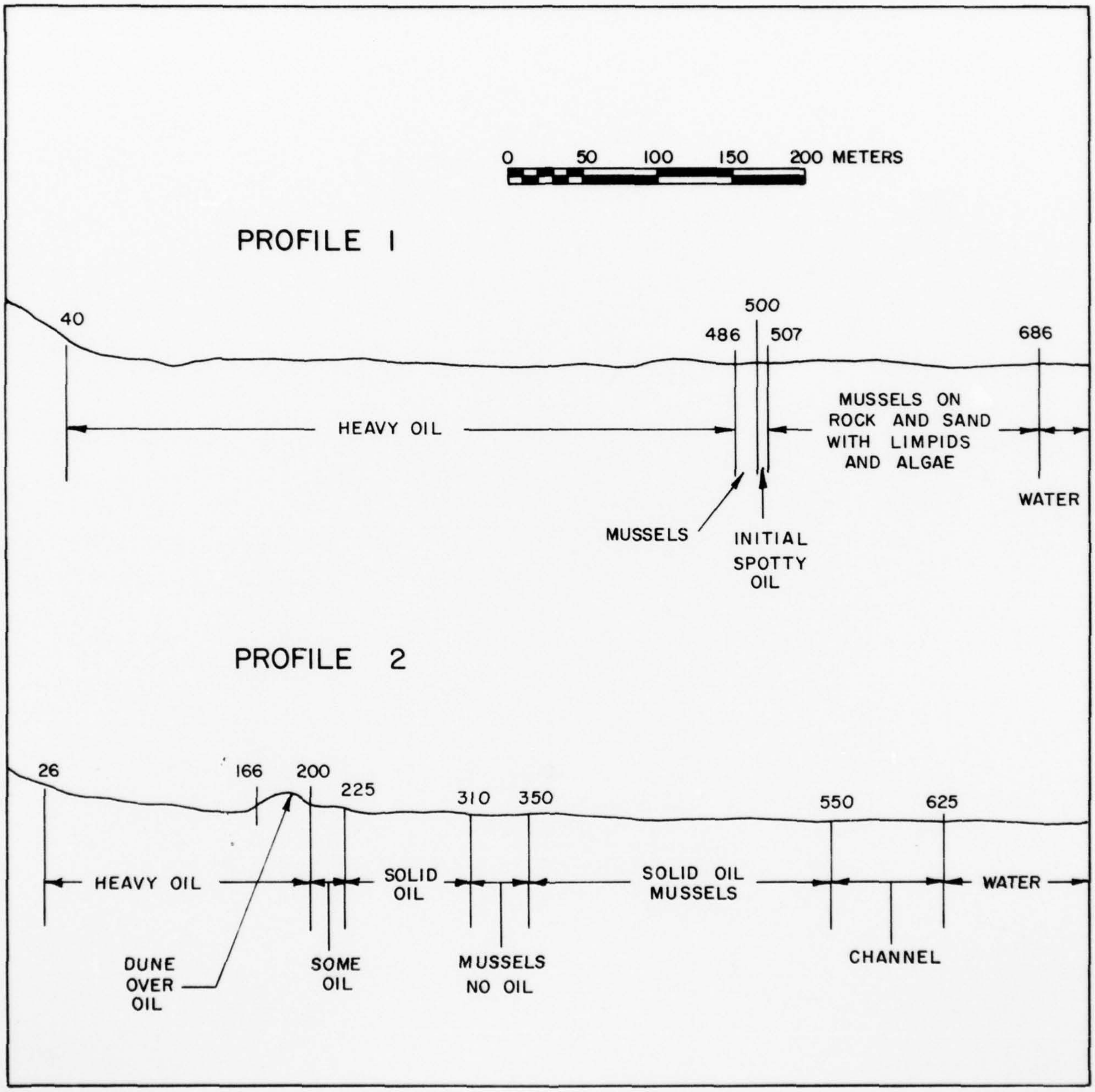


FIGURE 27

PROFILES OF AREA OFFSHORE WEST ESTUARY

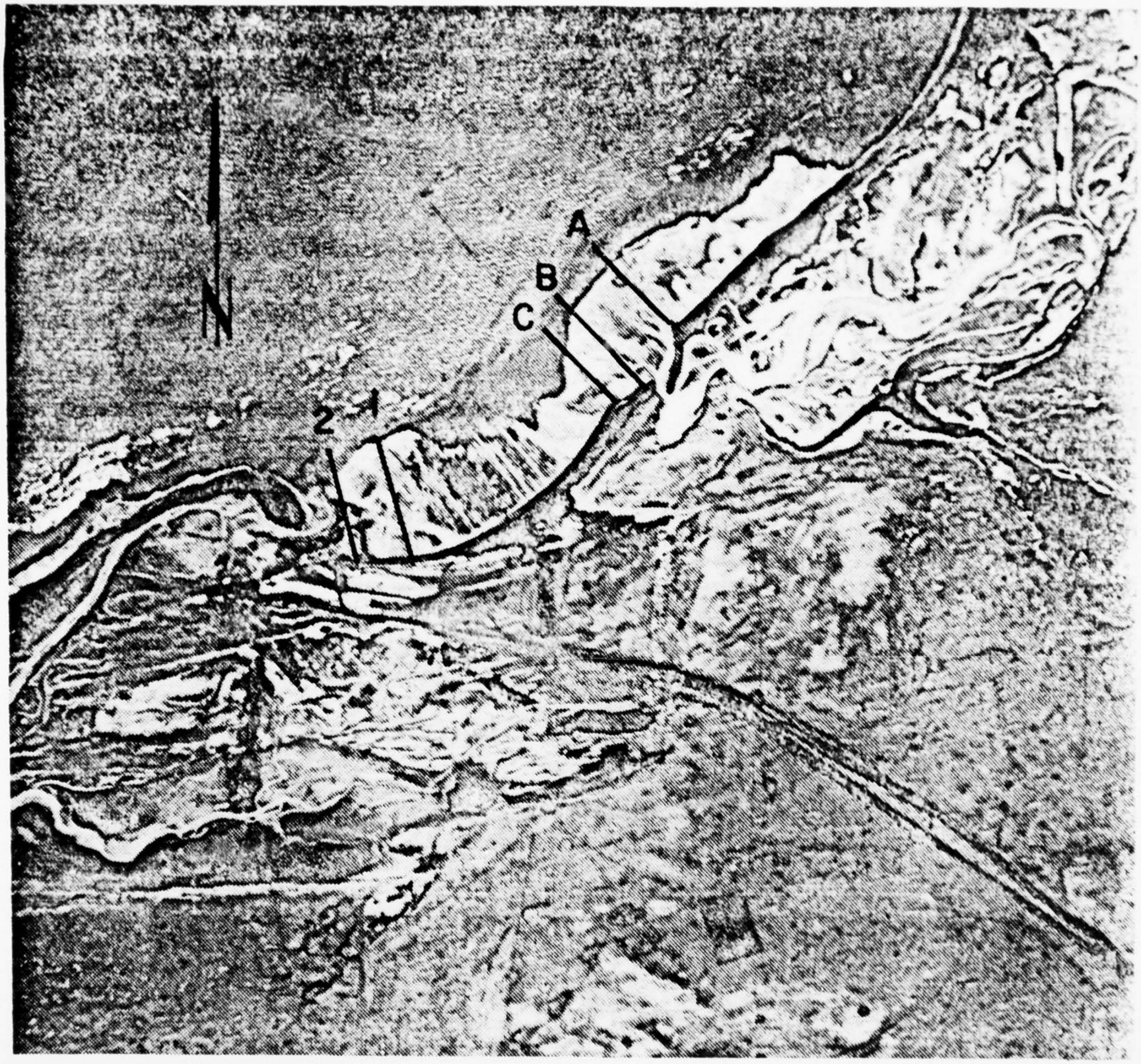


FIGURE 28

BEACH PROFILE ESPORA FLAT NEAR ENTRANCE OF EAST ESTUARY

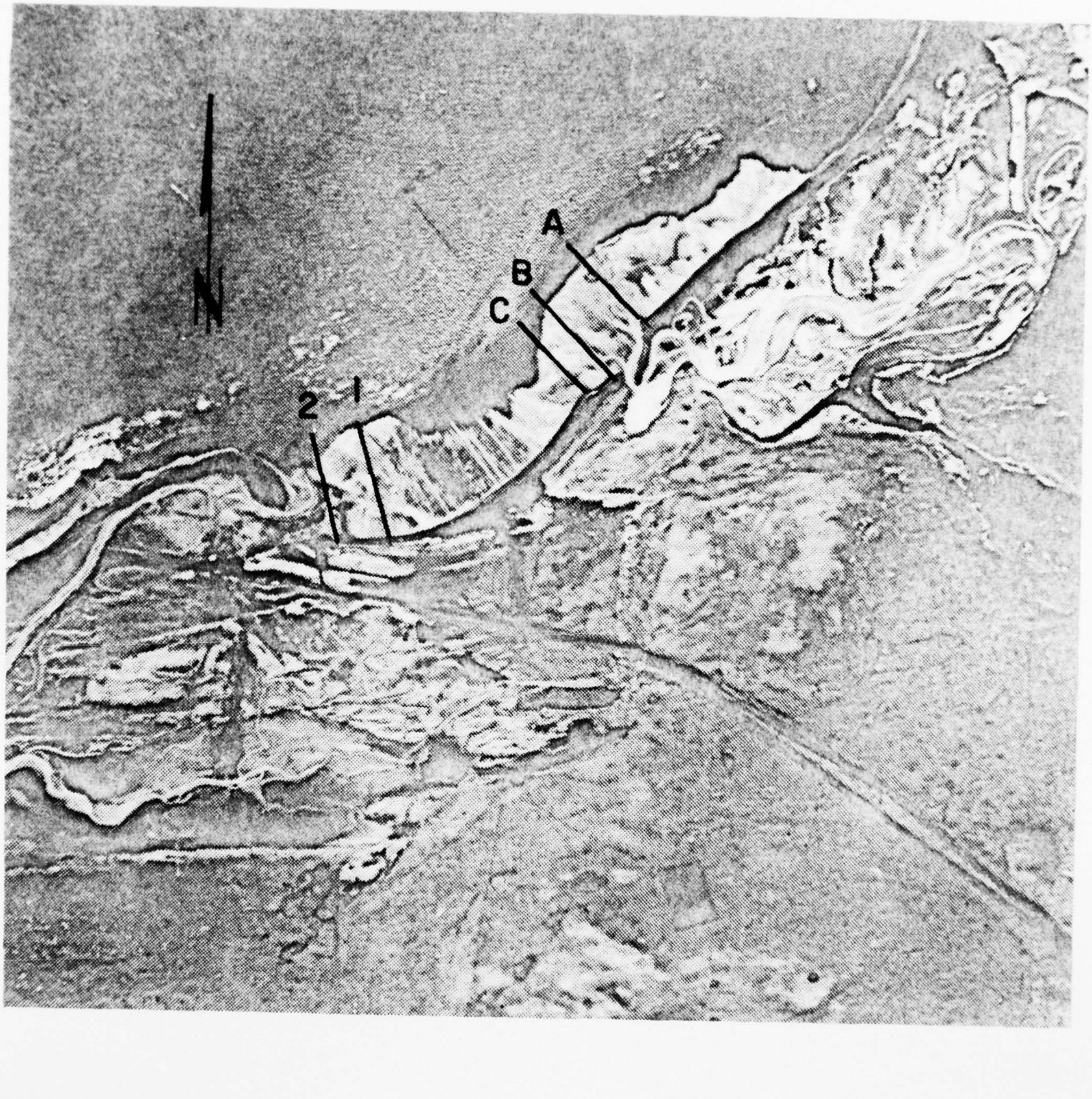


FIGURE 28

BEACH PROFILE ESPORA FLAT NEAR ENTRANCE OF EAST ESTUARY

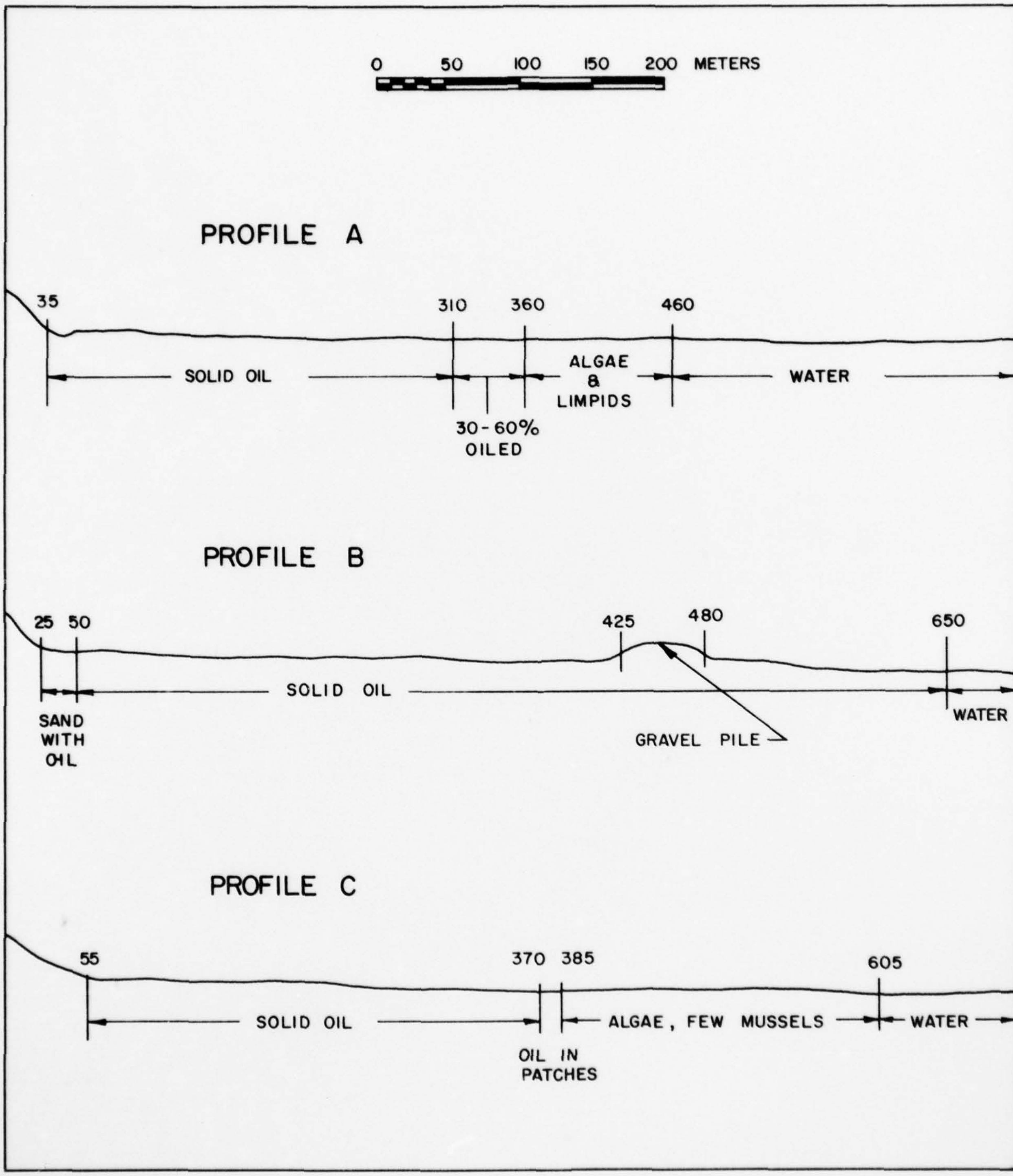


FIGURE 28

PROFILES ACROSS ESPORA FLATS

Figures 27 and 28 show five profiles made across the Espora Flat in 1977. It may be noted that the oiled zone ranged from over 300 meters to 600 meters (110-220 ft) wide.

In several areas of the Espora Flat erosion of the paved areas is taking place. However, probably less than fifteen percent had been eroded as of January 1978. It is considered likely that much of the paved sediment will still be in place ten years after the spill.

West Estuary

The West Estuary which enters the Espora area is shown in Figure 29. The West Estuary proceeds inland for 2 to 3 kilometers from the peninsula near Puerto Espora and bends 135° to the left and proceeds inland. Near its mouth the estuary has a deep channel some 10 meters (33 ft) deep which remains covered with flowing water even when the spring low tides occur. The entrance area of the estuary was covered in the same manner as the Espora Flats. However, there appeared to be less sand in the sediments and less blowing sand and thus, the mousse remained in its natural state longer. For example in January of 1975 it was quite difficult to maintain footing because the flat areas behaved as if coated with grease.

An oblique aerial view of the entrance area is shown in Figure 30 Part A. Figure 30 Parts B, C, D and E show views of an old pipeline and dock area at the West Estuary entrance. It is of interest to compare the depth of coverage in 1974 versus 1978. In 1978 the entire area along the pipe is still mousse covered, but the thickness has been reduced by weather and loss of water.

Figure 30 Part E shows the eroding lower edge of this deposit. It has only moved a few meters in the three and a half year period but does continually back oil into the West Estuary waters. The banks along the West Estuary were essentially paved with mousse in 1974. Figure 31 Part A shows an Environmental Protection Agency scientist viewing the paved north bank in January 1975.

At that time the northern bank of the channel above the low water line was reported to be heavily oiled with about a 5 centimeter (2 in)

thick moussecrete layer. The more gently sloping southern bank of the channel was reported covered with from 1 to 5 centimeters (.4 to 2 in) of mousse on top of moussecrete on clay. Since the level of wave turbulence inside the West Estuary is very low there has been almost no change in the coverage of the paved banks over the three and a half year period.

At the surface and further inland where the mousse layer was thin, the surface has weathered and hardened. Where the coverage was over 2 centimeters (.8 in) thick, however, the brown soft mousse is still found under the crust layer.

Figure 31 Parts B through D show views of the eroded and non-eroded areas in 1978 and a closeup of an eroding edge at the spring high tide level near the mouth where the limited erosion is taking place.

Further inland in the West Estuary are tidal flat areas originally covered with salicornia and large barren sand flats. Figure 32 Parts E, F, G, and H shows a sequence of photographs of one of these areas taken from 1974 through 1978.

This area, approximately one kilometer inland, is a broad tidal flat which has an oval shape some .5 kilometer wide and 1.0 kilometer long. A large mousse deposit some 800 meters long by 200 meters (2625 by 656 ft) wide and ranging from 2 to 4 centimeters (.8 to 1.5 in) in depth was reported in 1974 in this flat area. This area had changed little since the initial survey. This mousse had very little sand and debris mixed into it. The marsh was covered with salicornia, a marsh grass.

It may be noted that the same oiled areas are evident in each of the photographs. The texture and sheen of the oiled areas have dulled from

weathering, the settling of dust on the surface, the growing of algae on the surface and the tracking of sheep and wild animals through the oiled area.

Figure 31 Part E shows a newly oiled area in a salicornia patch in 1978. This oil had leached from a patch of older oil under the influence of summer sun and high tide and been deposited in a heretofore uncovered area. Figure 32 Parts A, B, C and D show various views of stranded mousse on the salt marsh and mud flats of the West Estuary in 1974 and January 1975.

It appears that the banks of the West Estuary will remain paved for a long period of time, perhaps on the order of from 10 to 20 years, and that the recovery of the salicornia flats in the inland portion will take an equally long time.

The bottom of the deep channel in the estuary has remained very productive in algae, kelp, mussels and other marine life. It appears that the continuous covering of water and the large volumes of water with high currents had minimized the impact in this small area.

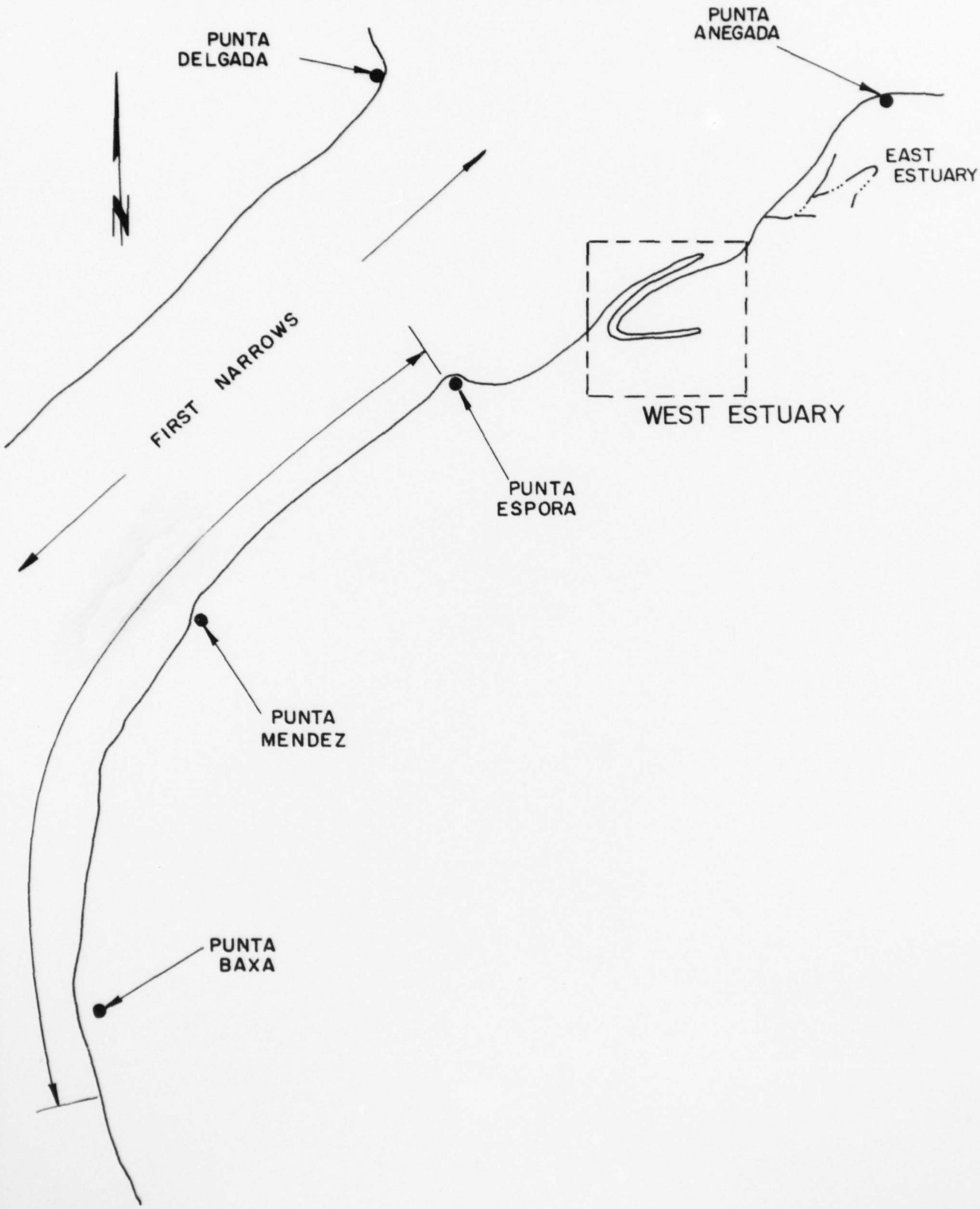
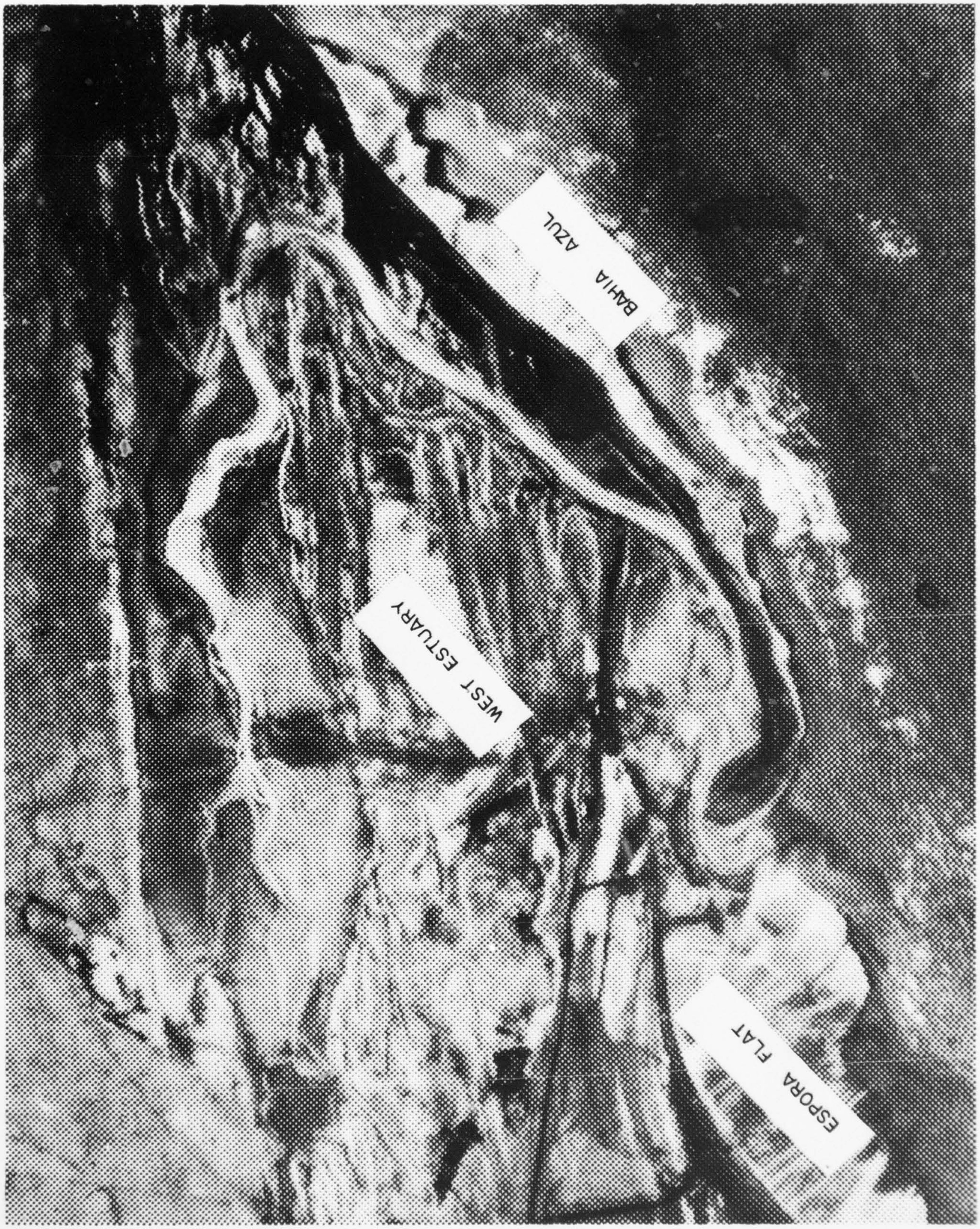


FIGURE 29

AERIAL VIEW OF WEST ESTUARY


BAHIA AZUL
WEST ESTUARY
ESPORA FLAT

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FATE OF OIL SPILLED FROM THE SUPERTANKER METULA.(U)
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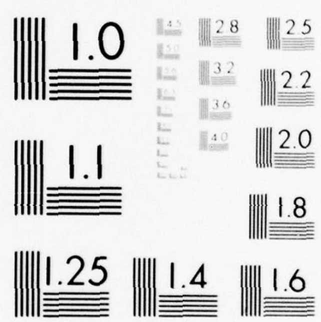

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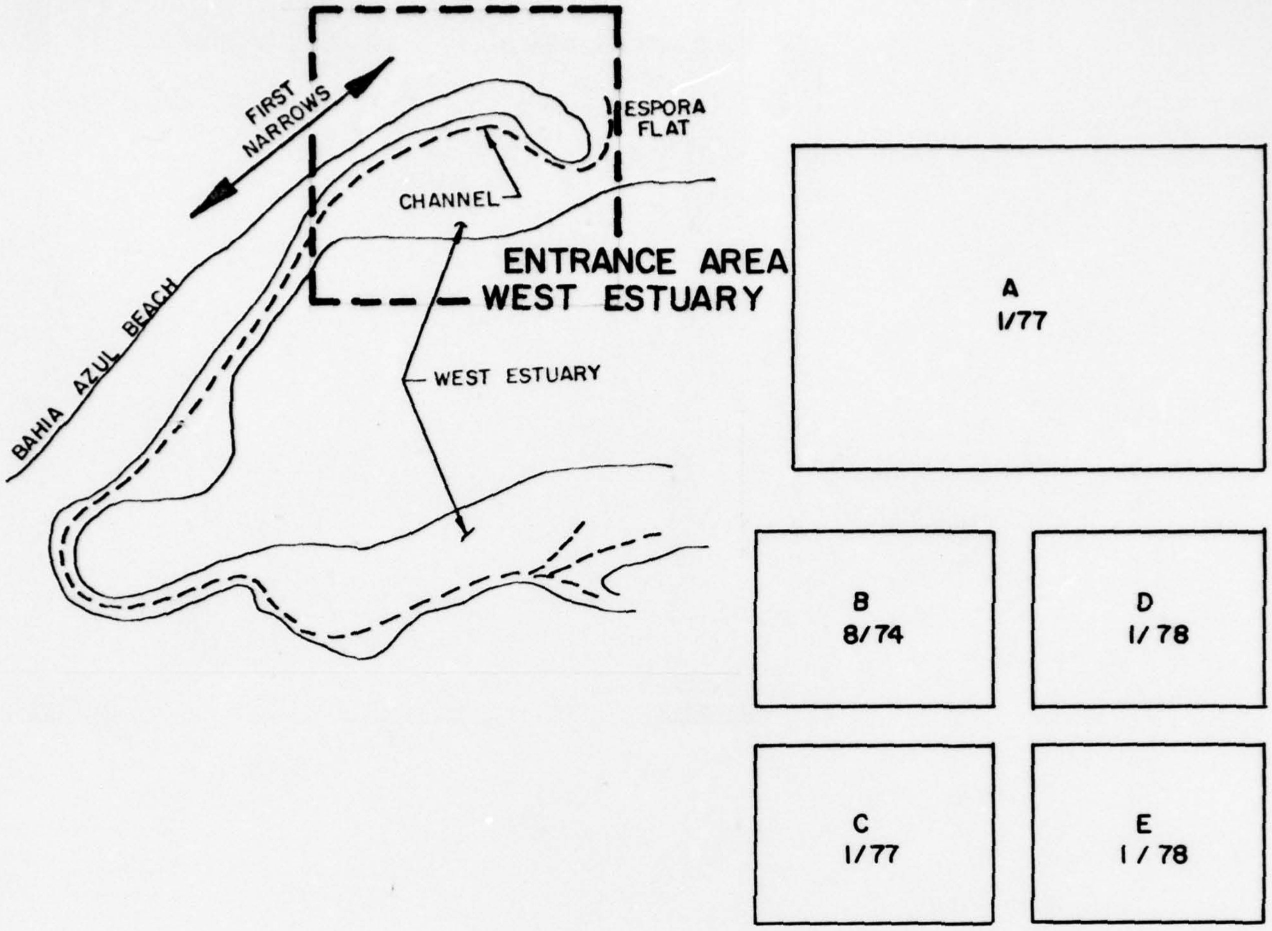


FIGURE 30

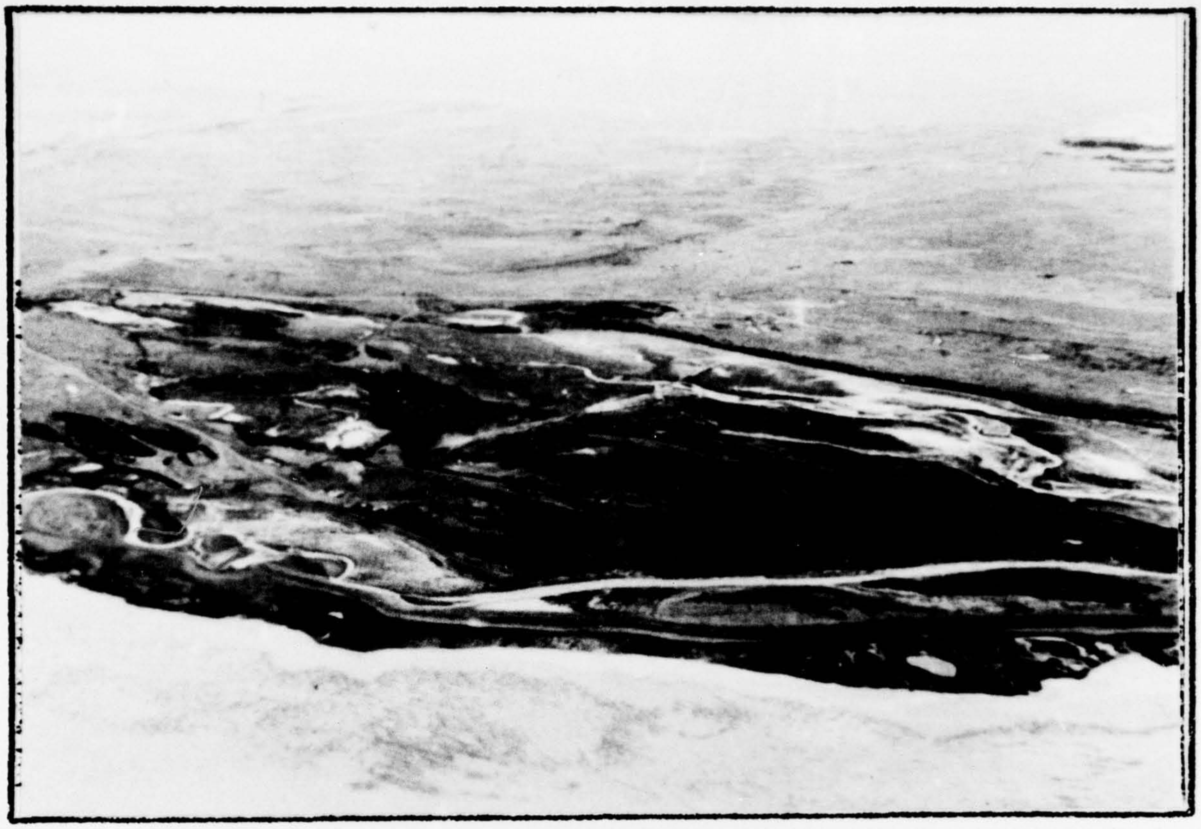
A - Aerial photograph of entrance to West Estuary at low tide.

B - Oil drum area near mouth of West Estuary in August 1974.

C - Aerial view of oil drum area in January of 1975.

D - Oil drum area near mouth of West Estuary in January 1978.

E - Eroding lower edge of oiled layer at oil drum area.



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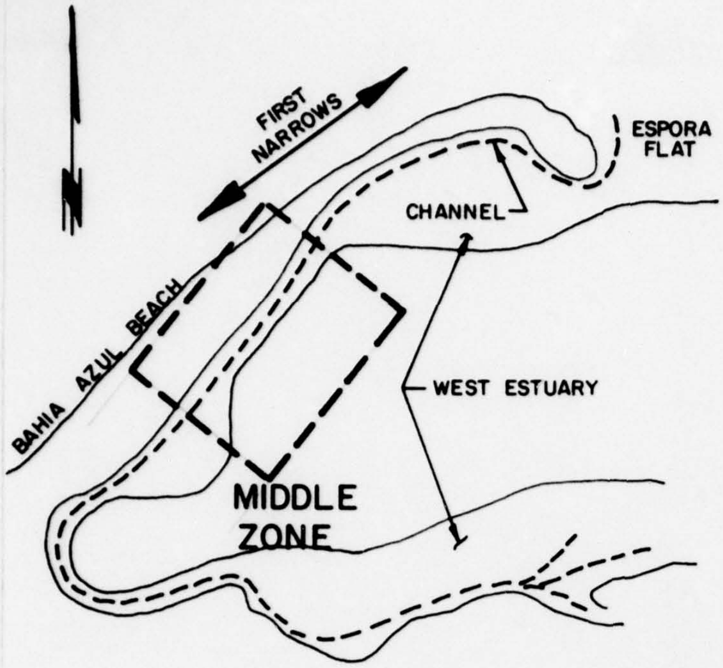


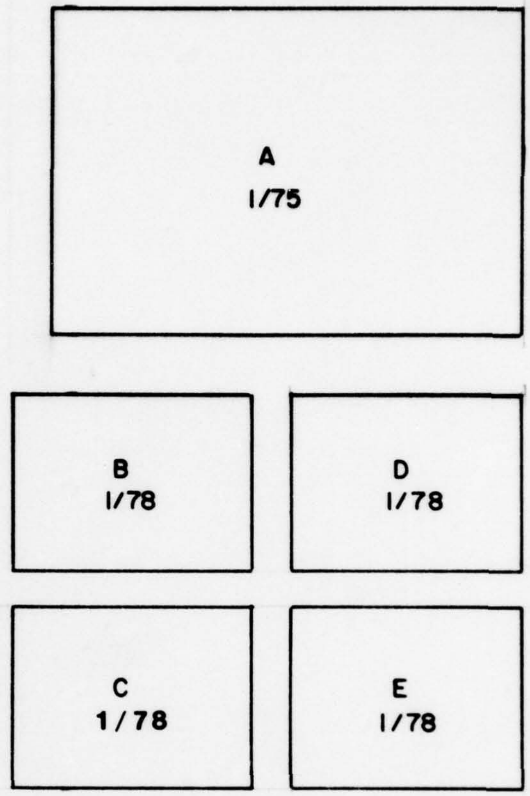


FIGURE **31**

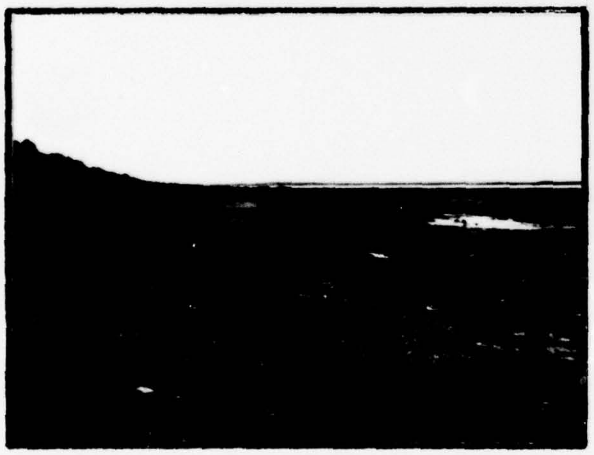
A - Oiled north bank of West Estuary in January of 1975.

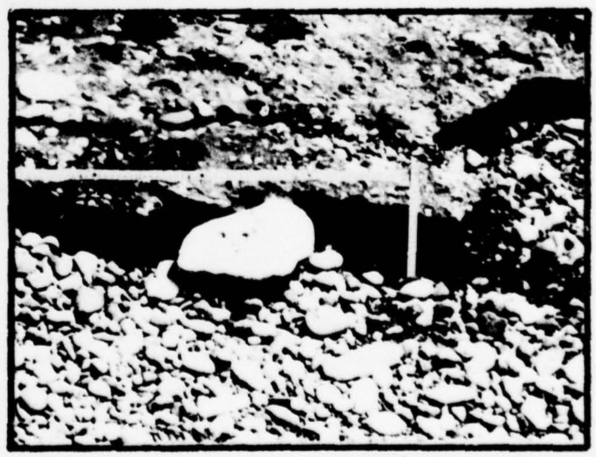
B - Eroding upper edge of paved bank on South Shore.

C - Another view of eroding upper edge.

D - Close-up of eroding edge.

E - Patch of Salicornia newly oiled by oil washed from previously oiled area on a warm day.





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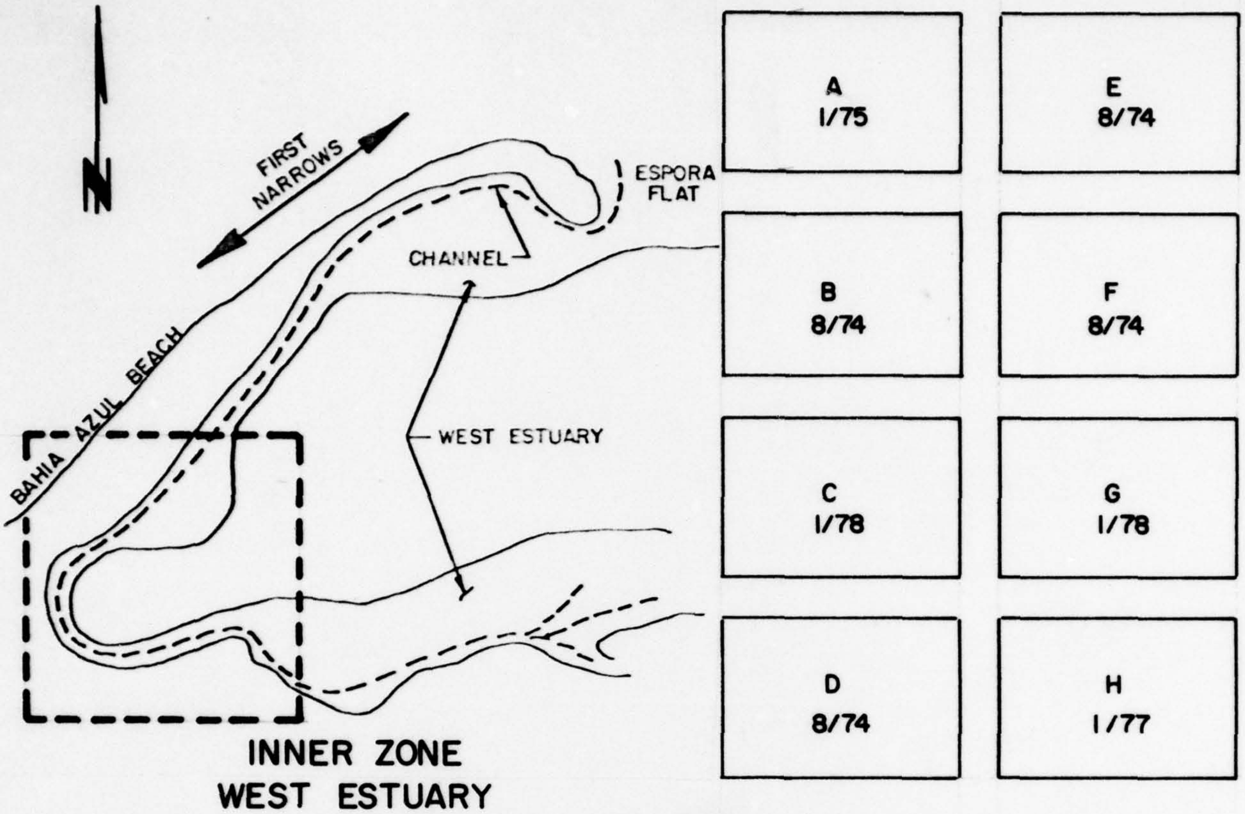


FIGURE 32

A - Oiled Salicornia area in tidal marsh.

B - Oil stranded on mud flat inside West Estuary bend.

C - Oiled Salicornia and pool of oil.

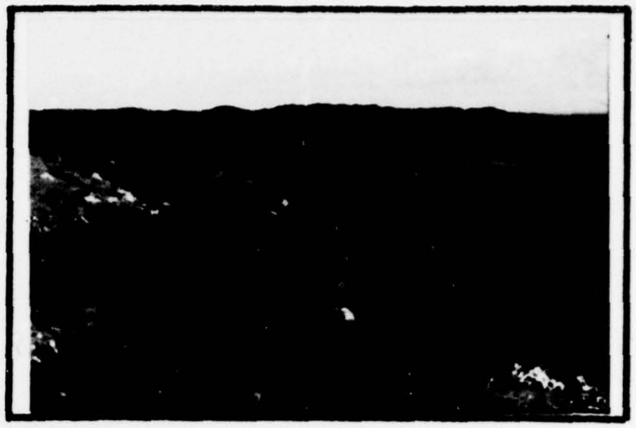
D - Oil stranded on mud flat.

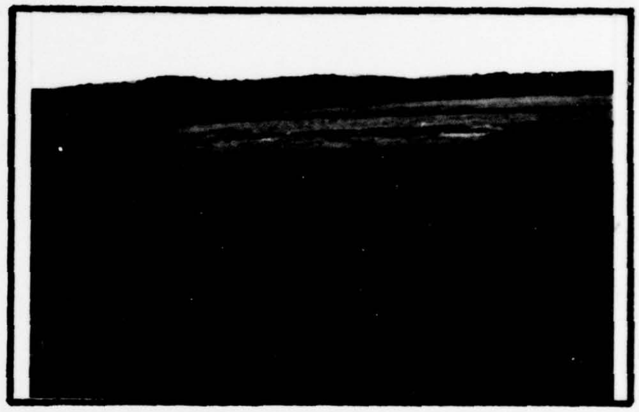
E - West Estuary Marsh 8/74

F - West Estuary Marsh 1/75

G - West Estuary Marsh 1/77

H - West Estuary Marsh 1/78





9/135

East Estuary

The East Estuary is a winding, twisting estuary which splits into several channels. The estuary drains a flat basin covered with grass and salicornia. Figure 33 shows an aerial photograph of the East Estuary and the Espora Flat over which the estuary drains. Figure 34 shows oblique aerial photographs of the estuary. Part A is taken from the Narrows looking shoreward and Part B from the back of the estuary looking toward the First Narrows.

The East Estuary differs from the West Estuary in that a bar is located at the mouth and flow from the estuary ceases when the water is lowered to the elevation of the bar. Some water is thus trapped in the channels between tidal cycles.

The East Estuary was so situated that the northwesterly wind forced mousse moving along the shore into this estuary in 1974 until it was essentially filled with oil. During high tides and winds, oil had been pushed into the flat grassland between the channels creating blackened vegetation and pools of oil which presented a desolate moonscape appearance.

Figure 35 Parts A, B, C and D show views of the entrance area of the estuary in January 1975. In this area depressions and secondary channels were filled with mousse from a few centimeters to over 25 centimeters deep. The sediments of the channels and the channel banks were covered with mousse and mousse up to several centimeters thick. Figure 35 Parts E, F, G and H show views of this area in 1977. The area has changed very little since originally oiled. Entire areas are grotesquely black with no vegetation recovering. Liquid mousse remains in depressions and the channel bottoms are paved with moussecrete from 8 to 15 centimeters

thick. An eroding edge can be seen only near the main estuary channel entrance where the edges of the deposits can be viewed.

The surface of the oil has blackened and in some cases algae and sediment form a thin film on the surface which dulls the appearance. Underneath, however, soft mousse is found everywhere.

The estuary channels from about one kilometer inland were reported completely filled with floating mousse to the ends of the smallest channels in the system in January 1975. The channels were estimated at that time to have from 20 to 30 centimeters (8 to 12 in) or more of floating mousse trapped in it. The mousse would rise and fall with high spring tides and recoat the channel walls and vegetation. These channels are shown in Figure 36 Parts A, B and C.

The mousse had been flushed from the channels by January of 1976, but the flat areas between channels and the channel bank as shown in Figure 36 Part D in 1975 and Parts E, F, G and H in 1977 and 1978 remained heavily oiled. This liquid mousse or oil on the surface remains in a soupy liquid form which has changed little in the three and a half years since the spill. Only in the areas where the mousse was not thick has the deposit thickened and hardened. This area will probably have evidence of the METULA spill for 15 to 20 years unless it is ultimately cleaned up.

FIGURE 33

AERIAL VIEW OF THE EAST ESTUARY FIRST NARROWS


ESPORA FLAT
ENTRANCE AREA
EAST ESTUARY
INNER CHANNELS

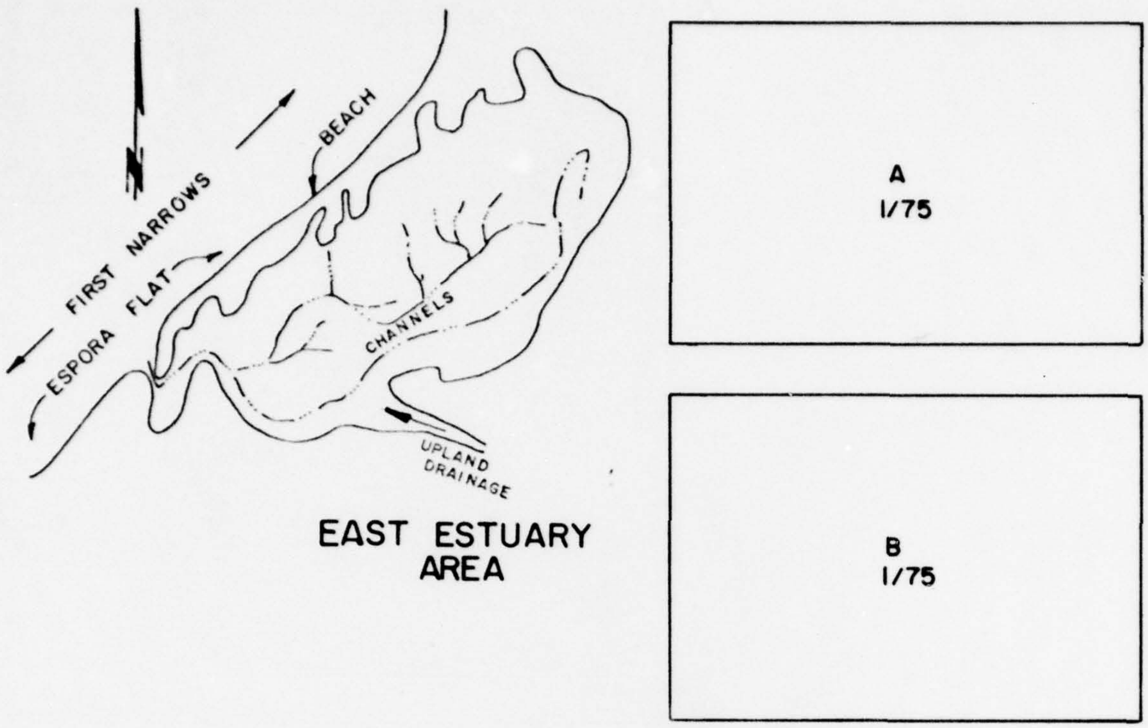
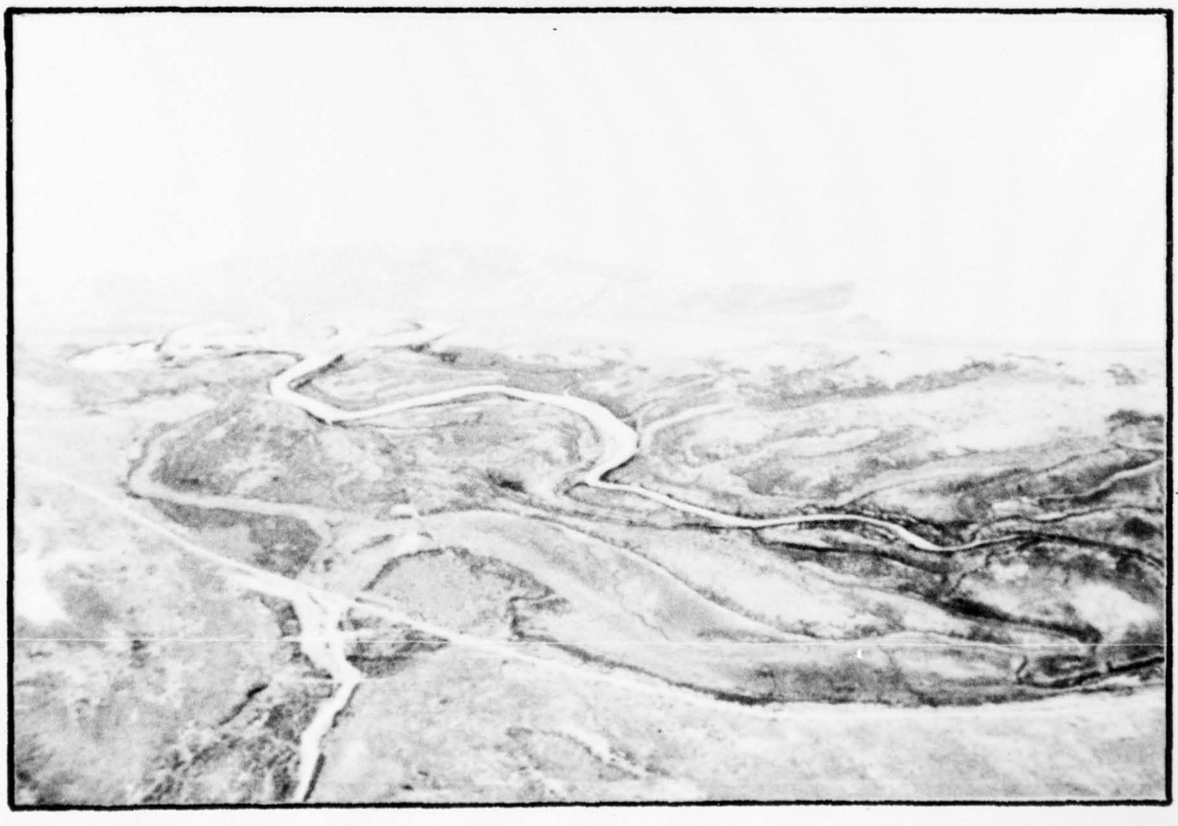


FIGURE 34

A - Aerial view of East Estuary looking south.

B - Aerial view of East Estuary looking northwest.



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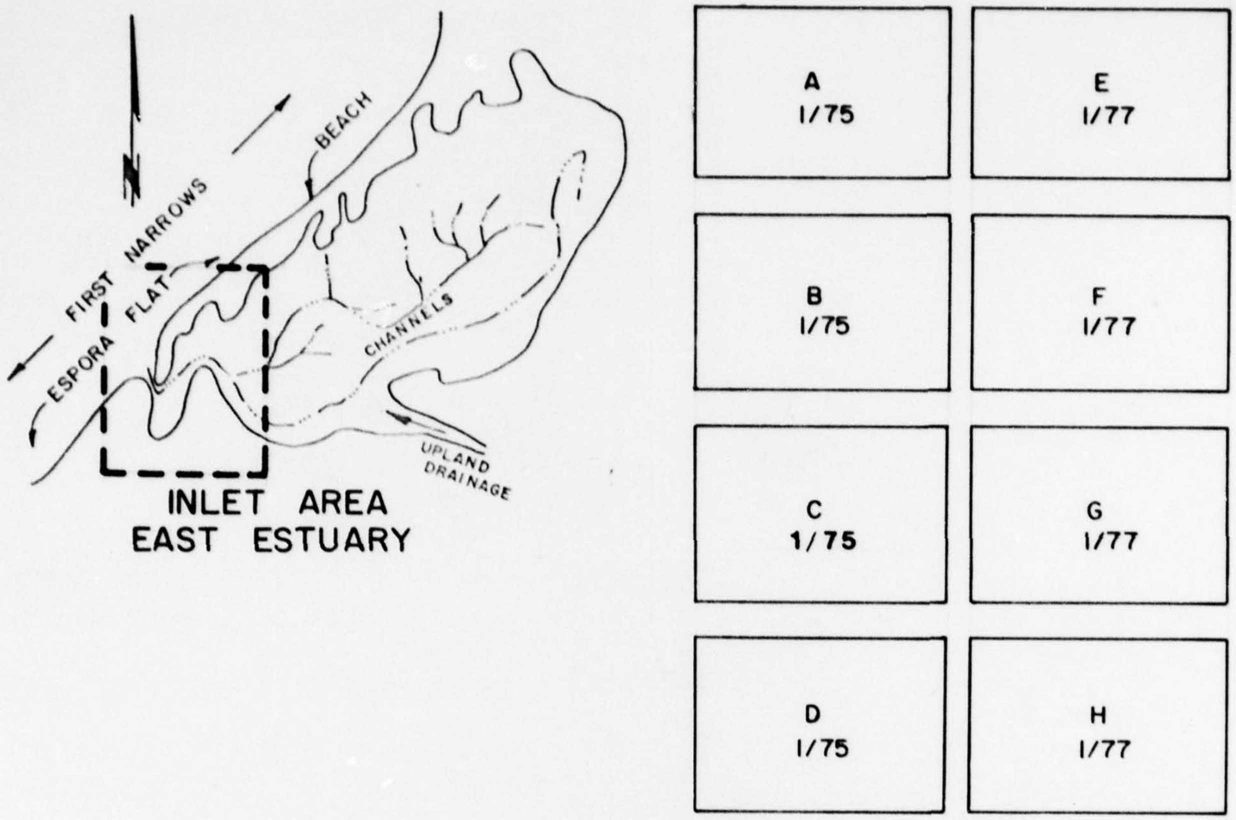


FIGURE 35

A - Aerial photograph of entrance area.

B - Bank of East Estuary near mouth.

C - Pooled oil near the entrance.

D - Oil in shallow depression near entrance.

E - Oiled basin near the entrance channel.

F - Oiled bottom of a bend in the East Estuary.

G - Close-up of oiled surface.

H - Eroding edge of oiled sediments.








8/140

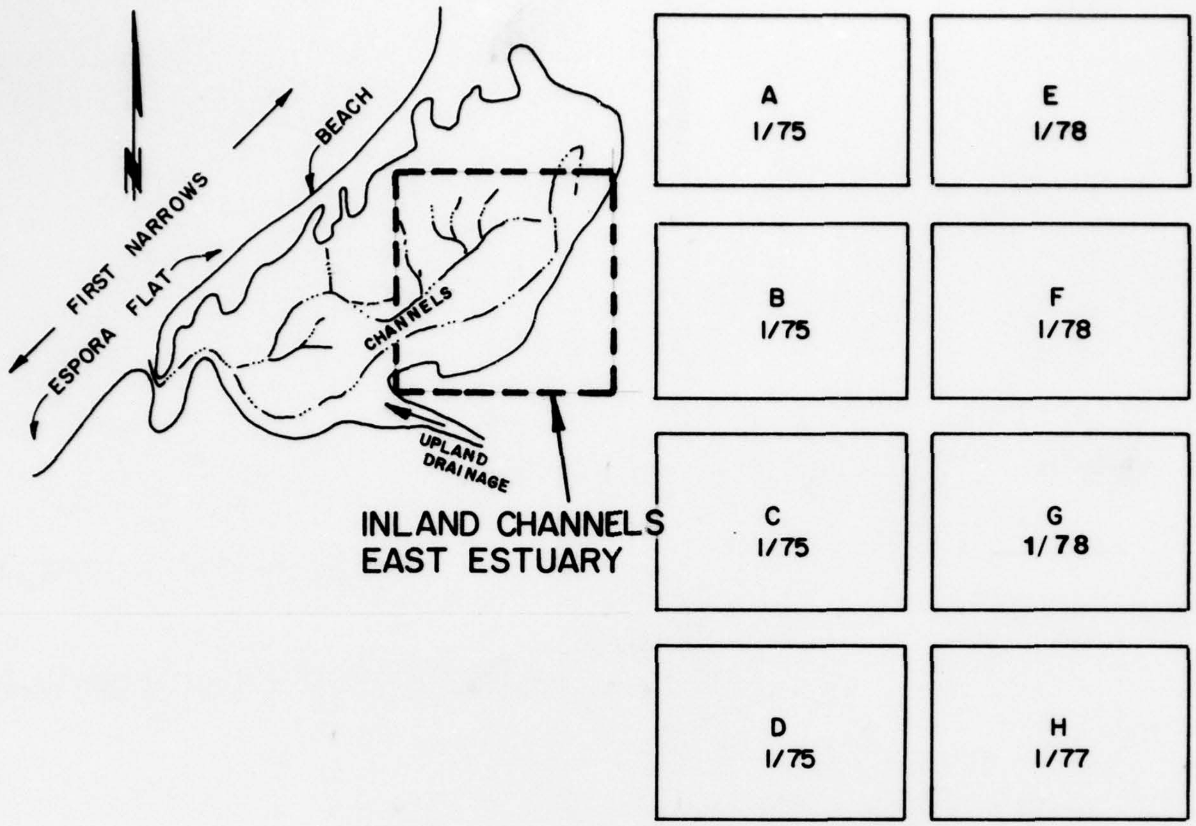


FIGURE **36**

A - Aerial view of inland channels showing oil on channel banks.

B - Close-up of channel edges showing oiled vegetation.

C - Thick pool of oil remaining in channel five months after the spill.

D - Isolated oiled vegetation on tidal grass flat.

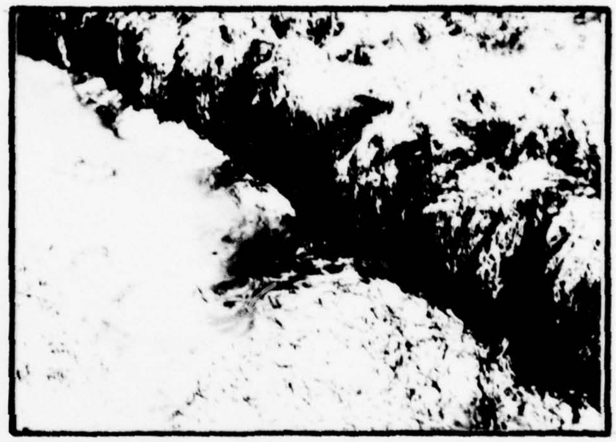
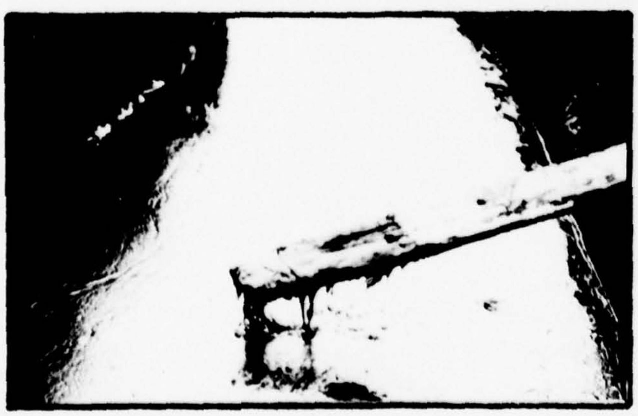
E - Oiled channel at later date.

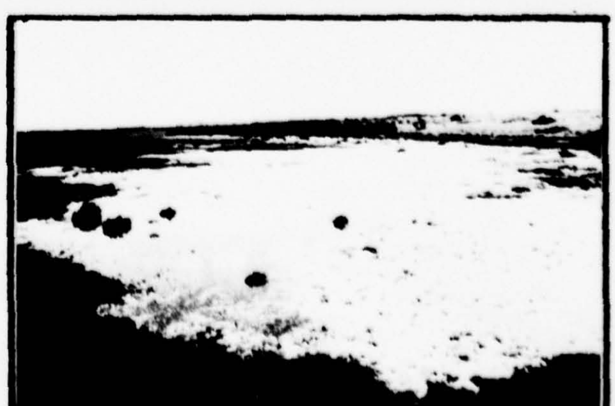
F - Oiled vegetation on banks 3 1/2 years after the spill.

G - Oiled channel 3 1/2 years after the spill.

H - Oiled pool on tidal grass flat 3 1/2 years after the spill.



7/135

Punta Anegada - Punta Catalina

The intertidal zone in Punta Anegada is identically the same as the Puerto Espora area. The amount of oil on the shore fell off rapidly as one proceeds several kilometers east of Punta Anegada at the time of the spill. Figure 37 Part A shows a typical section of this beach line in January of 1975. At that time a 2-to 4-meter (6-12 ft) zone of exposed mousse was observed on the surface and an area of covered mousse and oiled rocks was observed down the beach slope. As shown in Figure 37 Part B and D by 1977 this had eroded to an occasional crust of weathered oil and sand mixture at the top of the beach line.

Further east is a broad flat intertidal area west of Punta Catalina. This run appeared to have a heavy oil coating from the air at the time of the spill as shown by the aerial photograph in Figure 37 Part C but only this was probably a wide sheen of fresh oil that was photographed.

Investigation in January of 1975 showed only occasional oiled areas at the high tide zone as shown in Figure 37 Part D.

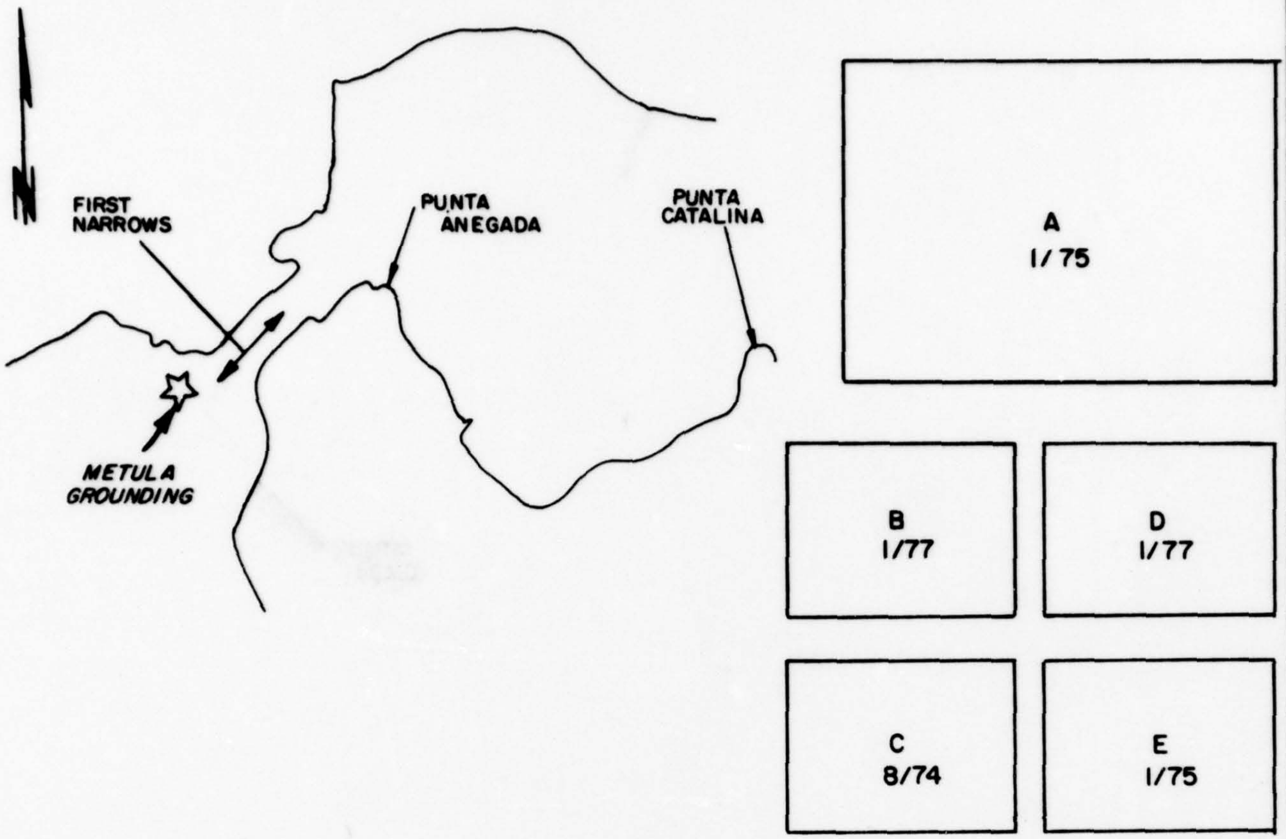


FIGURE 37

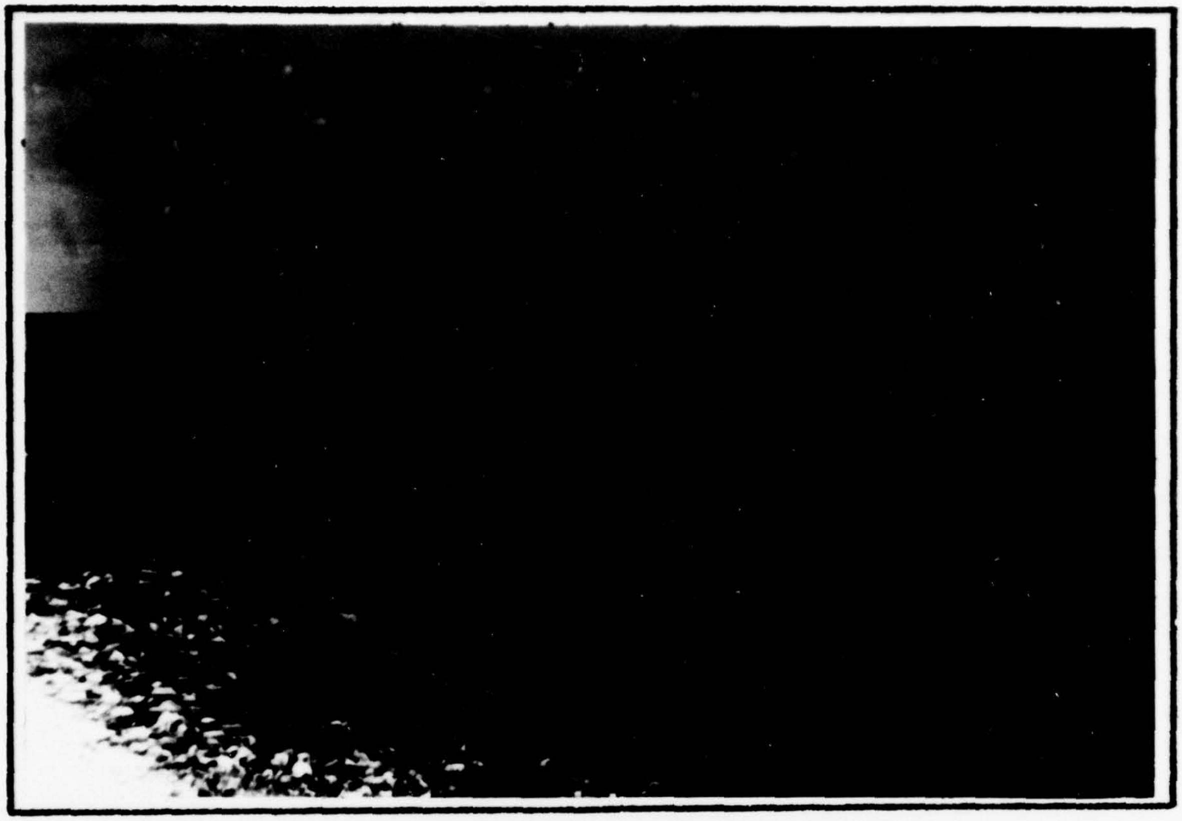
A - Oil at top of beach east of Punta Anegada.

B - Weathered oil at top of beach east of Punta Anegada.

C - Pooled oil sheen southwest at Punta Catalina.

D - Weathered oil crust at top of beach east of Punta Anegada.

E - Weathered oil at top of broad beach southwest of Punta Catalina.



Punta Posession to Punta Dungenes

The south shore of the continent to the east of the First Narrows between Punta Dungenes and Punta Posession was observed by air to be banded with mousse of varying widths in early September of 1974. The mousse in this area was deposited by the southwesterly wind of September 1, 1974 which stripped much oil from the south shore of the First Narrows. An aerial view of this deposit at that time is shown in Figure 38 Part A. The zone of the beach was first visited in January of 1975. At that time it was reported at a location 5 kilometers (3.11 mi) east of Pt. Posession, an 8-meter (26 ft) wide band of mousse mixed with sand ranging from a one-centimeter (.3/8 in) outcrop on one side to a 3 centimeter (1¼ in) on the other was observed. Occasional patches of mousse and slightly oiled rocks were observed outside this band.

Near an ENAP oil facility, approximately 18 kilometers (11.18 mi) west of Punta Dungenes, a layer of mousse mixed with gravel and rock was found which was approximately 6 meters (20 ft) wide and from 5 to 10 centimeters (2 to 4 in) in depth. The layer was covered with approximately 15 centimeters (6 in) of cobbles which were 25 percent covered with light oil.

Near Punta Dungenes an oil ledge was located some 2 meters wide and 5 centimeters (1½ in) deep which consisted of oiled rock and some occasional mousse.

The deposits on this shore remained in the normal high tide area rather than being blown higher and inland as on Bahia Felipe. Figure 37 Parts B and C show views of this area in 1975.

In 1978 extensive oiling was found on this shore near an ENAP sludge spill point and near Punta Dungenes where a recent ENAP oil spill took

place. Figure 38 Parts D and E show examples of these later spills. No oil was found, however, that appeared to be METULA oil. It is believed the location of these beaches so as to receive heavy surf from the strong westerly winds caused the oil to quickly dissipate into the water column.

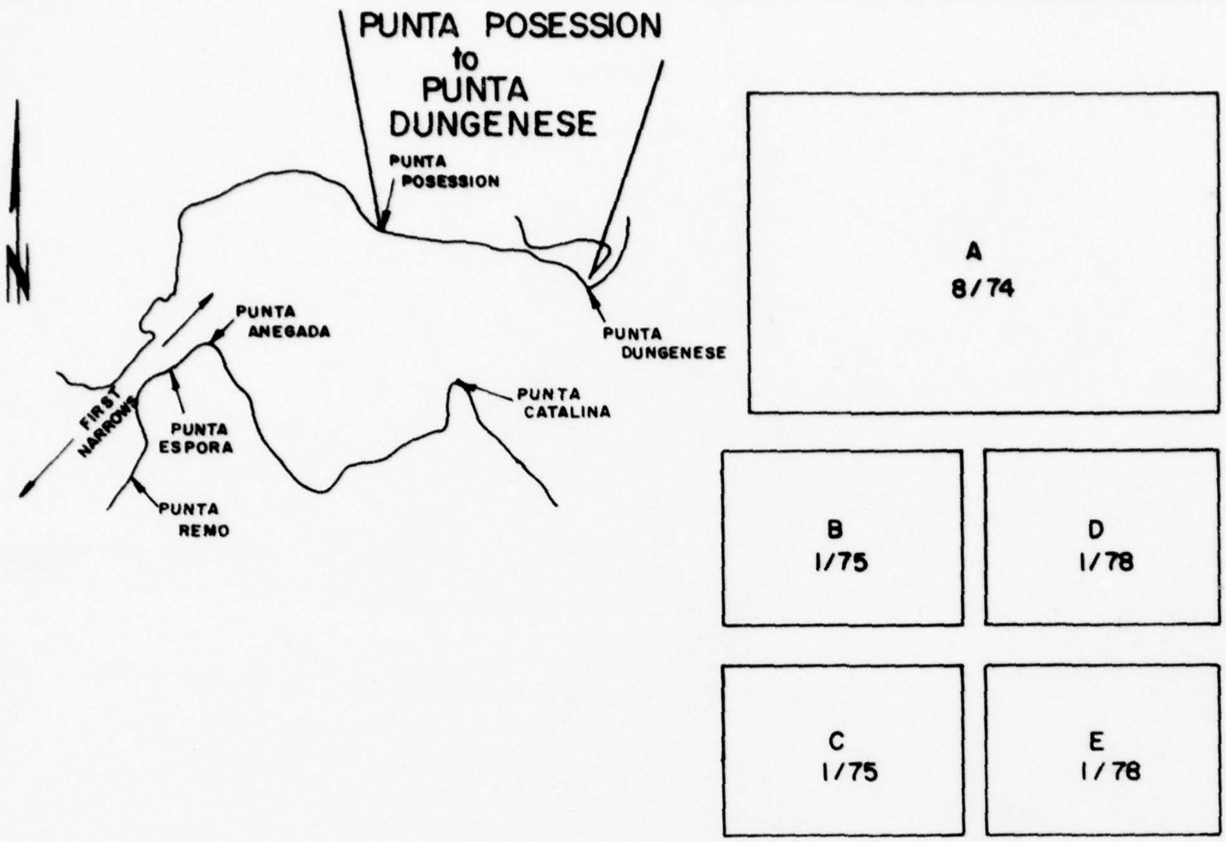


FIGURE **38**

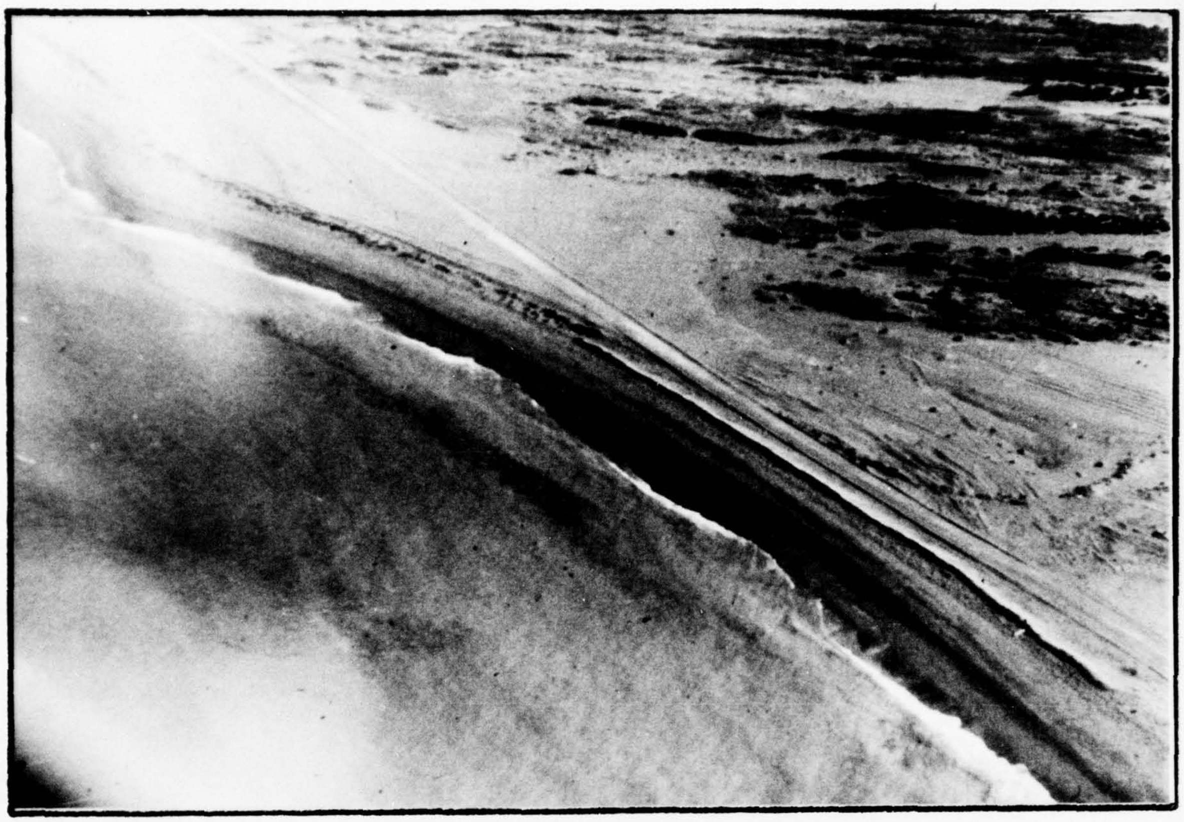
A - Stranded mousse at top of beach east of Punta Posession.

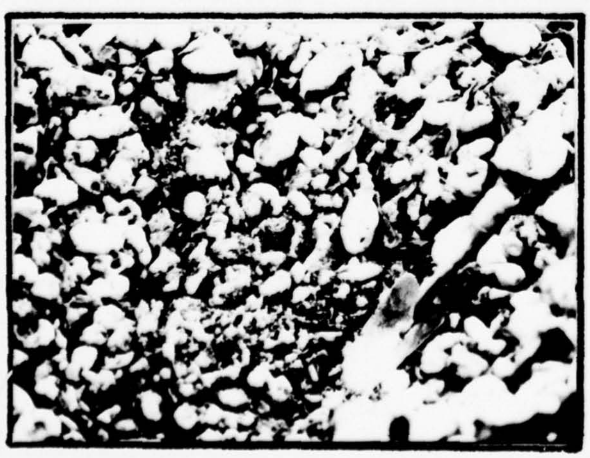
B - View of oil spotted rocks on the beach east of Punta Posession.

C - Closeup of oiled area on beach east of Punta Posession.

D - Oil patches of questionable origin east of Punta Posession.

E - New oil from non-METULA source near Punta Dungenese.





8/140

Marine Community

Other investigators will report more precisely on the impact of the METULA oil spill on the marine community. Nonetheless it is believed worthwhile for the author to discuss his observations of the marine community which was impacted.

Although a rugged environmental area, the cold but non-icing waters of the Straits and the windswept plains of the shore supports a substantial biological community. To truly appreciate the magnitude of the intertidal community one must visit the beach area during the spring low tides when the 11 meter low tide briefly exposes a wealth of marine organisms at the lower intertidal zone that is heavily cobbled. Figures 39 and 40 show various views of algae growing on rocks and oiled surfaces, mussel and limpet beds, crustacea on and around rocks and kelp and the organisms which live on it.

In the spill area there was a definite lack of crustacea when compared to the control area. There also appeared to be a decrease in limpets on the impacted coast, but a modest algal bloom appears to have triggered a strong comeback. The mussel community was undoubtedly affected, but live mussels were observed in areas where they were completely surrounded by mousse. A washed-out looking algae has even thrived on the surface of the moussecrete areas.

Marine mammals are represented in Figure 41 by porpoises which chase the ferries across the Narrows and the sea lion community on Isla Magdalena in the middle of the Straits.

Also shown are the graceful Guanacos which were photographed here with a few yards of the oiled shore of the Narrows and the ostrich-like Rias

which graze on the nearby hillsides.

The significant impact of the spill on waterfowl was reported in detail in the initial METULA report by the author. The greatest impact was on the cormorant and penguin communities. Figure 42 Parts A through D show oiled and dead cormorants and penguins at the time of the spill and in January 1975. Mummified oiled birds could still be seen in 1978 as shown in Part E of Figure 42.

The mystery as to the cause of death of over a hundred oiled and dead penguins observed in January of 1978 was solved when it was found that local fishermen were catching migrating penguins in their nets and wringing their necks to remove them. The bodies were then floating in the intertidal zone and coming in contact with oil spilled in November 1977 from an ENAP facility.

Figure 57 shows a selection of the penguin and cormorant rookery on Isla Magdalena in the middle of the Straits of Magellan. This island is the summer home of many of the birds in the Straits of Magellan area.

MARINE COMMUNITY

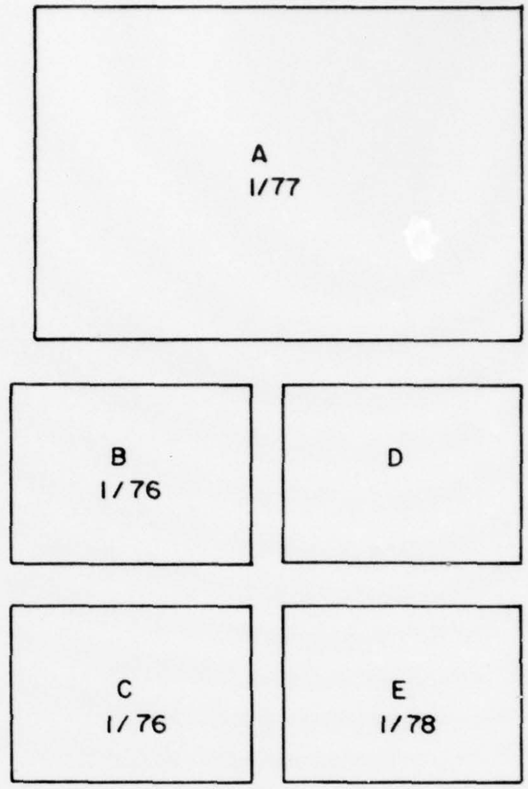


FIGURE 39

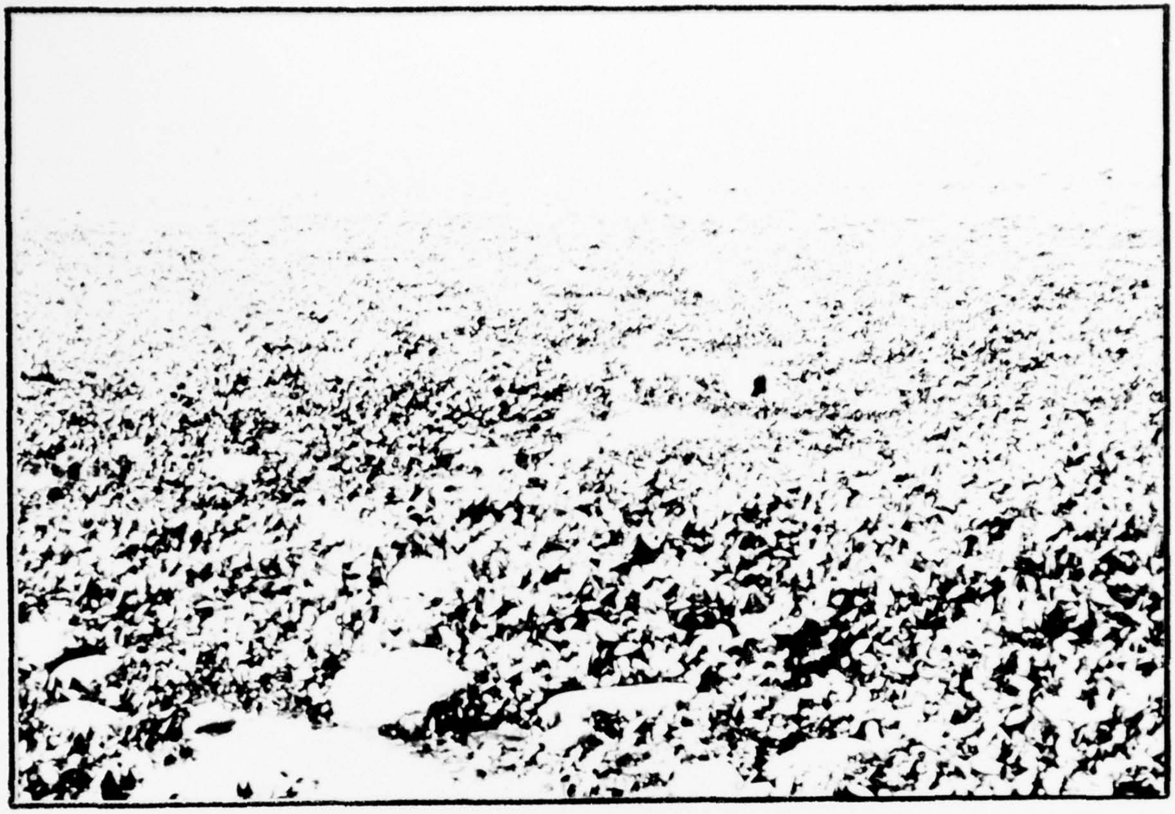
A - Dense mussel colony on the southeast arc of Bahia Felipe.

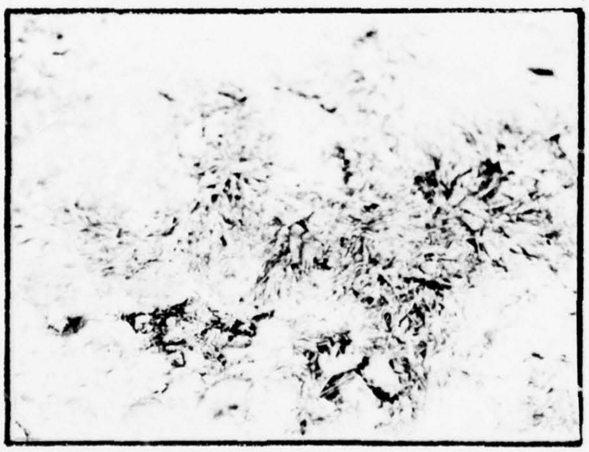
B - Algae growing on oiled sediment.

C - Large mussel colony on rock in lower Intertidal Zone.

D - Limpets and mussels.

E - Initial sign of crustacea on south shore of Narrows.





7/145

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MARINE BIOLOGY

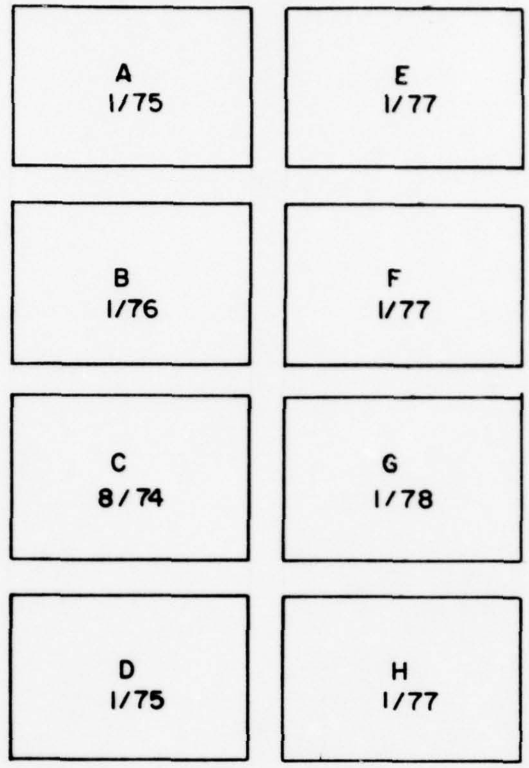


FIGURE 40

A - Mussels paved with mousse in Espora area.

B - Mussel community in lower intertidal zone Espora area.

C - Starfish impacted by oil on Espora Flat.

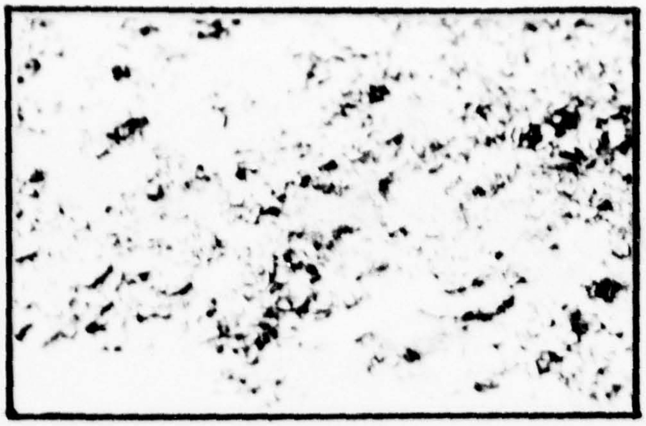
D - Group of organisms collected from freshingly beached kelp.

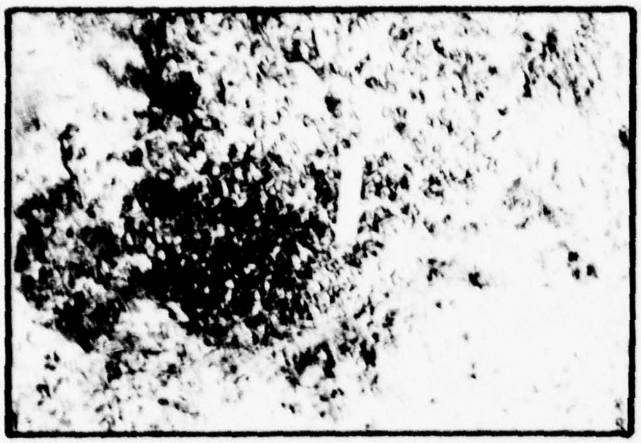
E - Dense mussel bed in lower Intertidal Zone at Bahia Felipe.

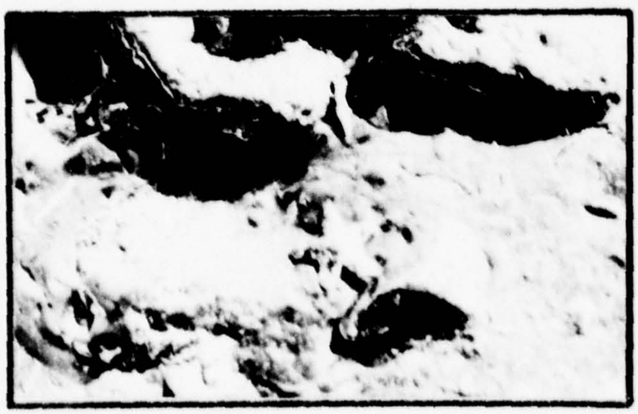
F - Blooming limpet population on south shore of Bahia Felipe.

G - Organisms laying eggs on Punta Baxa area of Bahia Felipe shore.

H -







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MAMMALS &
LAND BIRDS

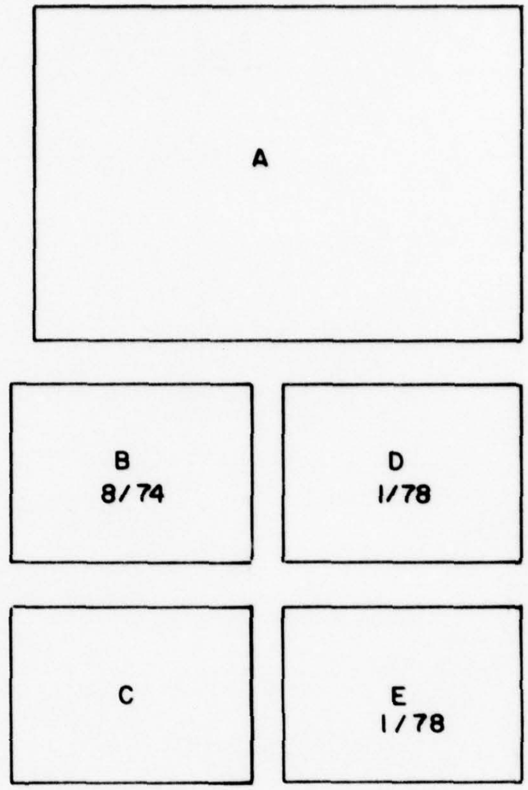


FIGURE 41

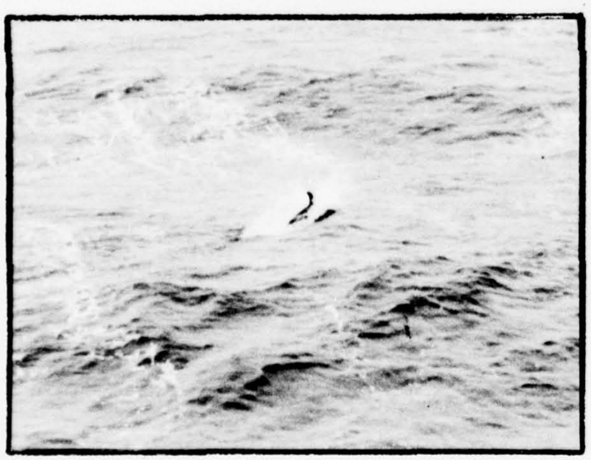
A - Sea Lion community on Isla Magdalena in the Strait of Magellan.

B - Porpoise in Ferry Wake.

C - Close-up of Sea Lion, Isla Magdalena.

D - Guanaco's near beach on Tierra del Fuego.

E - Ria's near beach road near Punta Posession.



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WATERFOWL

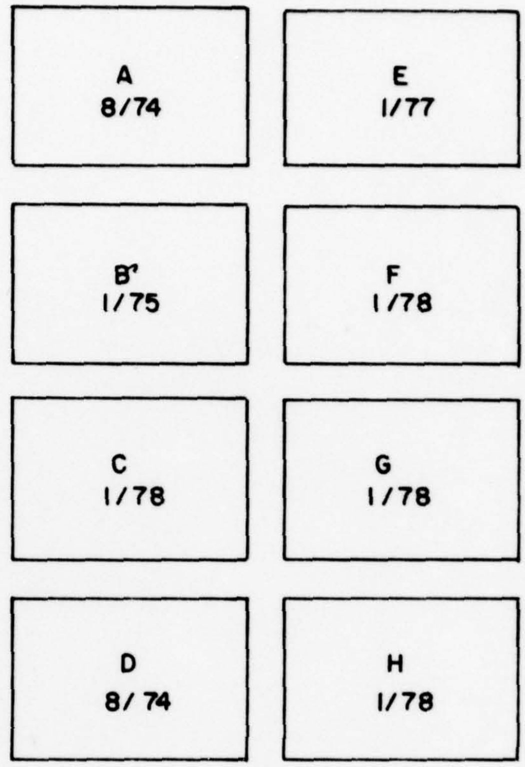

FIGURE 42

A - Oiled Cormorant near Punta Espora.

B - Group of 22 dead cormorants found within a 15 meter radius east of Punta Anegada.

C - Oiled dead Penguin.

D - Oiled Penguin.

E - Oiled dead Penguin.

F - Oiled dead Penguins near Punta Dungenes.

G - Penguins trapped in fish nets near Punta Dungenes.

H - Close-up of oiled dead Penguins killed in nets.

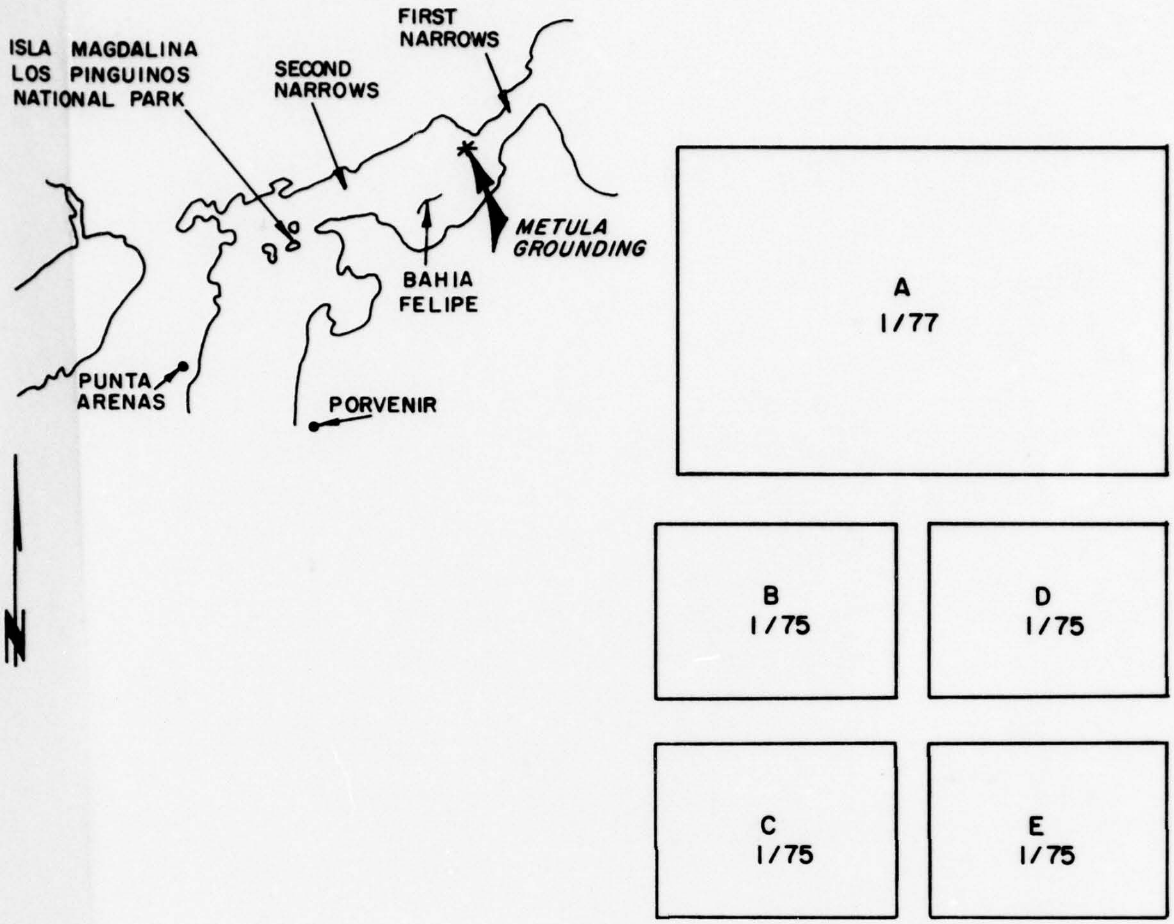

FIGURE **43**

A - Deserted lighthouse and occupied penguin burrows on Isla Magdalena.

B - Aerial photograph of Isla Magdalena.

C - Penguin welcoming committee on Isla Magdalena.

D - Cormorant colony on Isla Magdalena.

E - Typical penguin home and family on Isla Magdalena.

7/130

SECTION IV

OTHER METULA RESEARCH PROJECTS

At the time of the METULA spill, it was recognized that a number of investigators would study the METULA oil spill. These studies have ranged from simple visits to the site to major funded research activities. The author was asked as part of this project to seek the voluntary coordination of these projects.

The investigators have worked together exceptionally well and have shared field activities, exchanged project results and participated in a large number of conferences where the METULA spill was considered.

Table 3 is a list of the principal investigators of these projects, their organizations, sponsors, topic areas, and Chilean counterpart institution (if appropriate).

A summary of each project showing the principal investigator, his associates, his address, sponsor, METULA-related publications and a brief summary are included in Appendix I.

TABLE 3

METULA RELATED RESEARCH ACTIVITIES

Principal Investigator	Organization	Sponsor	Topic Area	Chilean Counterpart
Roy W. Hann, Jr.	Texas A&M	U.S.C.G.	Fate and Effect Coordination	Instituto de la Patagonia
Rita Colwell	Unv. of Maryland	N.S.F.	Microbial Degradation	Catholic Unv. of Valparaiso
John Emerick	NOAA	NOAA	Vegetation	Instituto de la Patagonia Unv. of Chile
Don Baumgartner Victor Gallardo	EPA	EPA	Sub-tidal Hydrocarbon	University of Concepcion
Miles Hayes Eric Gundlach	Univ. of South Carolina	N.S.F.	Beach geomorphology	Catholic Unv. of Valparaiso
Joseph Rule	Old Dominion	N.S.F.	Chemical Degradation	--
Scott Warner	Batelle N.W.	NOAA	Chemical Analysis of Tissue	--
Dale Straughan	Unv. of Southern California	NOAA	Intertidal Organisms	Instituto de la Patagonia
Jenny Baker	Field Studies Council	Shell	Marine Biology	Instituto de la Patagonia
Leo Guzman Italo Campodonico	Instituto de la Patagonia	Local Gov't. & Shell	Intertidal Biology	
Orlando Dollenz B. Edmundo Pisano V.	Instituto de la Patagonia	Local Gov't. & Shell	Oiled Vegetation	
Claudio Venegas	Instituto de la Patagonia	Local Gov't. & Shell	Penguin Population & Bird Repopulation	

SECTION V

LESSONS LEARNED FROM THE METULA STUDIES AND OTHER PROGRAM ACTIVITIES

The oil spill from the supertanker METULA has served three major useful roles. First it has served as a huge scientific experiment which has yielded useful scientific information.

Subsequent spills have shown us that the knowledge gained from the METULA spill is transferrable. The observation of the mousse formation and interaction with beaches and marshes has permitted and made it possible to provide guidance and recommendations to on-scene commanders in France and the United States that were faced with spills with similar behavior.

The various studies carried out with regard to this spill are described in the previous section and in Appendix I. The reader is encouraged to seek the results generated by the individual investigators.

Secondly, it has provided a vivid example that Mother Nature cannot be relied upon to rapidly overcome a spill of this type and magnitude that is not cleaned up. The prospect of the METULA oil remaining ten years and even longer at the beach tops, in the East and West Estuary entrances and in the Espora Flats has caused many who would counsel against cleanup in similar circumstances to reconsider their views.

Thirdly, the METULA has led us to observe how ill-prepared many countries are to cleanup a major oil spill. This lack of preparation not only refers to the lack of specialized oil pollution equipment and training to use it but also to the lack of fundamental plans, organizational structure, and technical policy decision as to how to deal with a spill if it occurs.

The participation in this project has led the principal investigator to see the need for a variety of activities related to such spills and has permitted the taking of a few initial steps toward the development of programs to fulfill these needs.

These needs are perceived in three specific areas:

1. better scientific and engineering response to a spill,
2. development of International training courses,
3. International technical assistance in contingency plan development.

Each of these areas will be discussed below and the activities initiated by this and subsequent projects identified.

The author responded to this spill with only his background knowledge and a camera. It quickly became evident that a properly trained, equipped and funded scientific and engineering team in coordination with local scientists could have provided important information relating to environmental conditions, oil behavior, oil movement, oil interaction with the beach and technical aspects of suitability of cleanup methods at sea and on the shore. It also would be better prepared to document what was happening from day to day and would be better prepared to gleen new scientific information from the spill itself.

Important benefits of this project have been the establishment of a prototype technical response plan and a prototype technical response equipment package based on the knowledge gained on the METULA spill and subsequent project activities.

The technical response plan is included in a draft document entitled Engineering and Scientific Studies Before, During and After a Spill which outlines a specific set of task items to be carried out in support of

contingency planning and spill response activities. Information on this program was presented to USCG, NOAA, EPA and USFWS at a personnel training session for the NOAA-EPA Oil and Hazardous Material Response team in Santa Barbara in December of 1978 and to USCG, USFWS and EPA personnel at a U.S. Fish and Wildlife Service training program in St. Petersburg, Florida in May of 1979.

The prototype technical assistance equipment package consisting of a command post Winnebago with logistical support facilities, a variety of transportation capabilities from portable boats to all-terrain vehicles and prepackaged air baggage transportable kits for surveying, chemistry, photo documentation and processing, color video documentation, meteorology, oceanography, hydrology, sampling, and visual aids have been assembled or developed with funding from the Texas Engineering Experiment Station.

Both the response plan and the equipment package were demonstrated at the Esso Bayway Oil Spill in the Neches Estuary in January and February of 1979. Technical input including maps and background information on the Neches Estuary, oil chemistry information, video and photographic documentation of spill conditions and calculation of impact areas and expected solid waste volume were provided to the U.S. Coast Guard On-Scene Commander and mentioned in the Pollution Reports from the spill.

The desire for training in oil spill control was expressed by both academic and government personnel in Chile during the author's trips subsequent to the METULA spill. As a result a two-day training course was developed by the project staff as part of this project and presented in Chile under the local sponsorship of the Chilean Navy and the Instituto de la Patagonia in August 1976. Some 150 attendees from academic institutions, government agencies, industry and the Navy participated in the

courses presented in Valparaiso and Punta Arenas. In view of this enthusiastic response the project activities relating to International training were expanded.

Ultimately reference materials, course notes, lectures and visual aids were acquired or prepared for a one-week course entitled Prevention, Abatement and Control of Pollution from Ships. The course outline for this course is presented in Appendix II, and the current course manual has been provided to the U.S.C.G. Project Officer. This course was subsequently presented under IMCO and UNEP sponsorship in Douala, Cameroon for the countries of West Africa and Cartagena, Columbia for the countries of the Caribbean.

The course is aimed at administrators, engineers and scientists who would have the responsibility for planning and executing spill response and for those responsible for policy decisions on International conventions relating to pollution from ships and on national issues such as funding for pollution response and acceptable cleanup technology.

The effective development of a National response to oil pollution can be aided considerably with technical assistance on contingency planning, location of technical literature and technical information on specialized oil spill equipment and supplies. The programs initiated by this project have utlimately led to a project in one major country to assist in all of these areas.

With regard to this project and Chile, the support was limited to the preparation of a list of initial equipment and supplies with backup technical literature from which the Chileans could make their initial requests for funds from their government and from outside funding agencies. This report was entitled Recommendations on Oil Spill Control Supplies

and Equipment for Chilean Ports. A copy is on file with the U.S. Coast Guard Project Officer.

In earlier reports the author reported his opinions with regard to the conditions at the time of the spill and the reasons that decisions were reached to not clean up the spill. It is hoped that the activities initiated by the author and other investigators relative to the METULA spill will permit a stronger scientific and engineering input to those who must make such decisions with regard to handling a spill in the future.

APPENDIX I

METULA RELATED PROJECTS AND PUBLICATIONS

NAME: Roy W. Hann, Jr.

ADDRESS: Environmental Engineering Div.
Civil Engineering Department
Texas A&M University
College Station, Texas 77843

ASSOCIATE: Harry N. Young, Jr.

ORGANIZATION: Texas A&M University

PHONE: 713/845-1418

SUPPORTING AGENCY: U.S. Coast Guard

PUBLICATIONS RELATING TO METULA SPILL:

1974, "Oil Pollution from the Tanker METULA," U.S. Coast Guard #AD/A-003 805/9WP.

1975, "Follow-Up Study of the Oil Pollution from the Tanker METULA," U.S. Coast Guard #AD-A017 100/9WP.

1975, "The Oil Spill from the Supertanker METULA and Its Significance on Legislation, Training and Research in Texas," Seminario Sombre Preservacion del Medio Ambiente Marino, Santiago, Chile.

1975, "The Supertanker METULA and Its Oil Spill: The World's Second Largest," Defenders of Wildlife.

1976, "Recommendations on Oil Spill Control Supplies and Equipment for Chilean Ports," Texas A&M University, College Station, TX.

1977, "Fate of Oil Spilled from the Supertanker METULA," 1977 Oil Spill Conference, New Orleans, Louisiana.

1978, "Physical Aspects of the Oil Spill from the Supertanker METULA," Conference on Assessment of Ecological Impacts of Oil Spills, Keystone, Colorado.

SUMMARY OF PROJECT:

The project has involved the periodic inspection of the spill site to observe the fate of the stranded oil and to observe the visible impact of the spill. The project has also included the coordination of U.S. scientists working on the spill.

A pilot program of training and oil spill control technical assistance has evolved to aid Chilean officials in dealing with oil pollution. The training materials so developed served as the basis of an International Oil Spill Training Program subsequently sponsored by IMCO and UNEP.

NAME: Roy W. Hann, Jr.

ASSOCIATE: Harry N. Young, Jr.

ADDRESS: Environmental Engineering Div.
Civil Engineering Department
Texas A&M University
College Station, Texas 77843

ORGANIZATION: Texas A&M University

PHONE: 713/845-1418

SUPPORTING AGENCY: U.S. Coast Guard

PUBLICATIONS RELATING TO METULA SPILL:

1974, "Oil Pollution from the Tanker METULA," U.S. Coast Guard #AD/A-003 805/9WP.

1975, "Follow-Up Study of the Oil Pollution from the Tanker METULA," U.S. Coast Guard #AD-A017 100/9WP.

1975, "The Oil Spill from the Supertanker METULA and Its Significance on Legislation, Training and Research in Texas," Seminario Sombre Preservacion del Medio Ambiente Marino, Santiago, Chile.

1975, "The Supertanker METULA and Its Oil Spill: The World's Second Largest," Defenders of Wildlife.

1976, "Recommendations on Oil Spill Control Supplies and Equipment for Chilean Ports," Texas A&M University, College Station, TX.

1977, "Fate of Oil Spilled from the Supertanker METULA," 1977 Oil Spill Conference, New Orleans, Louisiana.

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A pilot program of training and oil spill control technical assistance has evolved to aid Chilean officials in dealing with oil pollution. The training materials so developed served as the basis of an International Oil Spill Training Program subsequently sponsored by IMCO and UNEP.

NAME: Joseph Rule

ADDRESS: Old Dominion University
Geophysical Sciences Dept.
Norfolk, Virginia 23508

ORGANIZATION: Old Dominion University

PHONE: 804/489-6493

SPONSORING AGENCY: NSF-RANN

PUBLICATIONS:

None received.

PROJECT TITLE: Physio Chemical Reactions of METULA in Petroleum and *Beach Sediments* Affected by the METULA Oil Spill in the Strait of Magellan

SUMMARY OF PROJECT:

The project was funded to evaluate the physical-chemical reaction between crude oil from the METULA and various types of beach and tidal zone sediments in the Strait of Magellan. Project components include the relationship between texture and mineralogy, major and minor metals in the oil and on contaminated sediments and studies on the ease of exchange of metals.

NAME: Leonardo Guzman M.
Italo Campodonico G.
Edmundo Pisano V.
Orlando Dollenz B.
Claudio Venegas
Dolly Lanfrancol
Walter Sielfeld K.
Azize Alalah G.
Georgina Lembeye V.
Hugo Elias
Steve Langley
Bill Texera
Jean Texera

ADDRESS: Instituto de la Patagonia
Casilla 102-0
Punta Arenas - Magallanes
Chile

ORGANIZATION: Instituto de la Patagonia

SPONSORING AGENCY: Local government and a Royal Dutch Shell Company

PUBLICATIONS:

1975, "An Oil Spill in the Straits of Magellan," Jenifer M. Baker, Italo Campodonico, Leonardo Guzman, Jean Jory Texera, Bill Texera, Claudio Venegas and Alfredo Sanhueza.
1975, "Contamnacio por Petroleo del B/T 'METULA' en Vegatacion Fanerogamica Litoral, Vol. 7," Edmundo Pisano.
1977, "Estado de la Flora Vascular en Puerto Espora, Tierra del Fuego, Contaminada por el Petroleo del B/T 'METULA'. I. Reconocimiento de la Entrada de mar Noroeste," Orlando Dollenz A.
1977, "Algunos Antecedentes Sobre El Macrobentos, Granulometria y Contenido de Petroleo en los Sedimentos de dos Entradas de mar en Puerto Espora (Tierra del Fuego) Contaminados por el Derrame del B/T 'METULA'," Stephen P. Langley and Georginia Lembeye V.
1978, "Estado de la Flora Vascular en Puerto Espora, Tierra del Fuego, Contaminada por el Petroleo del B/T METULA," Vol. 9 Orlando Dollenz A. in press.
1978, "Estudios, Sombre Contaminacion por Petroleo en el Sector Nororiental del Estrecho de Magallanes, Chile," April.
1° Informe
2° Informe
3° Informe
4° Informe

SUMMARY OF PROJECT:

Study of the marine biology, terrestrial biology and birds of the area impacted by the METULA oil spill and a study of the penguin rookery on Isla Magdalena in the Strait of Magellan.

NAME: Miles O. Hayes

ASSOCIATE: Eric Gundlach

ADDRESS: Coastal Research Division
Department of Geology
University of South Carolina
Columbia, S.C. 29208

ORGANIZATION: University of South Carolina

PHONE: 803/777-6759

SUPPORTING AGENCY: NSF-RANN

PUBLICATIONS:

1975, Coastal Geomorphology and Sedimentation of the METULA Oil Spill Site in Straits of Magellan: Report to Advanced Environmental Research and Technology, NSF, Washington, D.C. 103T. With others.

1976, Abstract, The Great Patagonian Oil Spill: AAPG-SEPM Annual Convention, May. With others.

1977, Report of the Coastal Environment to the METULA Oil Spill in the Straits of Magellan, Santiago, Chile: Geological Society of American Annual Meeting, Seattle, Washington, Nov. With others.

1979, Some Guidelines for Oil Spill Control in Coastal Environments Based on Field Studies of Four Oil Spills: ASTM Symposium Williamsburg, Virginia, Oct., in press.

TITLE OF PROJECT: Distribution of Spilled Oil in Relation to Beach Morphology

SUMMARY OF PROJECT:

The project involved the establishment of a landform and sedimentological classification of the beaches in the Straits of Magellan which were affected by oil spilled from the tanker METULA and the use of this classification, in connection with knowing the extent of damage in each geomorphic class, to indicate the amount of potential spill damage to be expected on similar beaches in New England and Southern Alaska.

NAME: Dale Straughan

ADDRESS: Institute for Marine & Coastal Studies
University of Southern California
Los Angeles, California 90007

ORGANIZATION: University of Southern California

PHONE: 213/741-2258

SPONSORING AGENCY: National Oceanic and Atmospheric Administration (NOAA)

PUBLICATIONS:

1975, "Biological Survey of Intertidal Areas of the Strait of Magellan in January 1975, five months after the METULA Oil Spill," Final Report to MESA Program Office, MESA TM 10.

1976, "Intertidal Biological Studies of the METULA Oil Spill in the Straits of Magellan,"Sea Grant Publication, University of Southern California USC-SG-76.

1977, "Intertidal Biological Studies of the METULA Oil Spill in the Straits of Magellan, January 1977," Symposium on Long Term Recovery Potential of Cold Water Marine Environments after Oil Spills" Dartmouth, Nova Scotia, October (unpublished).

1978, "Biological Studies of the METULA Oil Spill," Proceedings AIBS Conference, Keystone, Colorado, June, pp. 364-377.

SUMMARY OF PROJECT:

Two intertidal field surveys have been conducted - January 1975 and January 1977. The sample techniques involved replicate biological samples in quadrats in the intertidal area with additional samples and measurements in the same quadrats to measure possibly related abiotic parameters, e.g. intertidal height, grain size and oil content of sediments. These quadrats were selected along gradients from heaviest to non-oiled areas and from high tide to low tide.

The surveys to date show that there is a large natural biotic variability in the Straits of Magellan. In addition, there was "recovery" from the oil spill in some areas but continued impact of the oil spill in heavily oiled areas two and a half years after the spill. The area should continue to be surveyed to document the final recovery from the oil spill.

NAME: Jenifer M. Baker

ADDRESS: Field Studies Council
Oil Pollution Research Unit
Orielton Field Centre
Pembroke Pembrokeshire, ENGLAND

ORGANIZATION: Oil Pollution Research Unit

PHONE: Castlemartin 225

SPONSORING AGENCY: A Royal Dutch Shell Company

PUBLICATIONS:

1974, "Grounding of METULA: Magellan Straits Ecological Survey, 9th September - 4th October, 1974. Unpublished report, Oil Pollution Research Unit, Pembroke, England.

1975, "An Oil Spill in the Straits of Magellan," unpublished report, Oil Pollution Research Unit, Pembroke, England. With others.

1975, "An Oil Spill in the Straits of Magellan," Proceedings, Conference on Marine Ecology and Oil Pollution, Aviemore, Scotland: 441-471. With others.

SUMMARY OF REPORT:

The project included a field survey during October 1974. Information is presented on the movement and fate of the METULA oil and the condition of the flora and fauna including, intertidal and splash zone organisms, kelp beds, birds, mammals, and fisheries.

NAME: Rita R. Colwell

ADDRESS: Department of Microbiology
Division of Agriculture and Life Sciences
University of Maryland
College Park, MD 20742

ORGANIZATION: University of Maryland

SPONSORING AGENCY: NSF-RANN

PHONE: 301/454-5376

PUBLICATIONS:

1977, "Microbial Ecology Studies of the METULA Spill in the Straits of Magellan," Proceedings, Oil/Environment - 1977, Halifax, Nova Scotia, Canada, October. With others.

1978, "Microbiological Effects of Petroleum Accumulation on Beaches," Draft Final Report to the National Science Foundation. With others.

SUMMARY OF PROJECT:

The project evaluated the biodegradability of METULA oil by different bacteria and included a survey of heterotrophic bacteria and measurement of the impact of METULA oil on sediment bacteria.

NAME: Charles Gunnerson

ADDRESS: NOAA - MESA Program
Environmental Research Labs
Boulder, Colorado

ASSOCIATE: George Peter

PHONE: 303/499-1000 Ext. 6387

ORGANIZATION: National Oceanic and Atmospheric Administration

SPONSORING AGENCY: NOAA

PUBLICATIONS:

1976, "The METULA Oil Spill: A NOAA Special Report," September. With George Peter.

SUMMARY OF PROJECT:

Development of a summary report in 1975 based on field studies in January 1975, published reports and a special conference in Boulder, Colorado in June 1975.

The report examines the spill background, physical geography, environmental observations, cleanup considerations, lessons learned and research needs relating to the METULA spill.

NAME: John Emerick

ADDRESS: MESA-Domes Project Office
ERL/NOAA
Boulder, Colorado

ORGANIZATION: National Oceanic & Atmospheric Admin.

PHONE: 303/499-1000

SPONSORING AGENCY: NOAA

PUBLICATIONS:

None received.

SUMMARY OF PROJECT:

Study of the vegetation impacted by the METULA oil spill. Participated in January 1977 field program.

NAME: Victor Gallardo

ADDRESS: Coastal Pollution Research
Environmental Protection Agency
200 S.W. 35th Street
Corvallis, Oregon 97330

ASSOCIATE: Don Baumgartner

PHONE: 503/757-4722

ORGANIZATION: University of Concepcion

SPONSORING AGENCY: Environmental Protection Agency (EPA)

PUBLICATIONS:

Report pending.

SUMMARY OF PROJECT:

Evaluation of sediment samples collected from the NSF HERO in the Straits of Magellan during the spring of 1976.

NAME: Scott Warner

ADDRESS: Batelle Columbus, N.W.
505 King Avenue
Columbus, Ohio 43201

ORGANIZATION: Batelle N.W.

SPONSORING AGENCY: NOAA

PUBLICATIONS:

1975, "Determination of petroleum components in samples from the METULA oil spill," Final report to MESA Program Office, MESA Data Report 4.

SUMMARY OF PROJECT:

Laboratory evaluation of hydrocarbon in the tissue of intertidal organisms called by Dale Straughan in January of 1975 and 1977.

TIMETABLE

INTERNATIONAL COURSE ON THE PREVENTION
AND CONTROL OF OIL POLLUTION

Cartagena, Columbia
October 23-27, 1978

MONDAY, October 23, 1978

Morning:	Overview of the Oil Pollution Problem
8:00	Registration
8:30	Welcoming Remarks
9:00	Oil Pollution and Its Control in Perspective Movie: Oil
10:00	Course Objectives, Format and Support Materials
10:30	Examples of Specific Oil Spills AMOCO CADIZ: The World's Largest METULA: South America's Largest BAY MARCHAND: A Production Related Spill
Afternoon:	Prevention of Oil Pollution from Ships and Shoreside Facilities
1:15	The Role of Prevention as a Control Method
1:30	Operational Pollution Sources on Tankships
2:00	Alternate Methods of Controlling Ballast Water and Tank Washings Movie: Load on Top Movie: Cleaner Tanks - Cleaner Seas
3:30	Reducing the Risk of Oil Spills Due to Collisions
4:00	Design and Procedures to Minimize Spillages from Ships During Loading and Unloading Movie: Oops! Movie: We Are At the Controls

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TUESDAY, October 24, 1978

Morning:	Basic Steps in Oil Spill Cleanup Programs Containment and Removal Technology
8:00	Properties of Oil that Affect Cleanup and Environmental Damages
8:30	Behavior of Oil in and on Water Movie: API Oil Spill Control
9:30	Unit Processes and Unit Operations for Oil Spill Cleanup Programs
10:00	Concepts of Containment Devices Movie: High Seas Oil Containment
Afternoon:	
1:15	Hydrologic and Hydraulic Properties of River Systems Which Affect the Movement and Containment of Spilled Oil
1:45	Properties of Bays and Estuaries that Affect the Movement and Containment of Spilled Oil
2:15	Specific Containment Devices Movie: Cleanup - Some Basic Tools of Oil Spill Cleanup in Navy Harbors
3:30	The Selection and Use of Sorbent Materials Movie: 3M Oil Sorbent Movie: Conweb Oil Sorbent Movie: Oil Sorbent Harvesting System

WEDNESDAY, October 25, 1978

Morning:

8:00	Predicting the Movement of Spilled Oil Movie: Forecast for Survival
9:30	Deployment of Containment Devices Movie: Operation Preparedness

Afternoon:

1:00	Removal of Spilled Oil by Skimmers Movie: Spill Recovery Movie: Cyclonet
2:45	Construction Use of Traditional Equipment and Levels of Resources Required
3:00	Environmental Systems Subject to Impact by Oil Movie: A River Must Live Movie: Steel Reefs

THURSDAY, October 26, 1978

Morning:	Chemical Control Agents	
8:00	Use of Chemicals to Disperse or Contain Oil Movie: Exxon Dispersant Film Movie: A Clean and Pleasant Land Movie: API - Dispersants from Aircraft	
9:30	Considerations for Policy on Dispersant Use	
10:00	Impact of Oil on Beach, Rocky Areas and Marsh Environments	
11:00	Environmental Studies Before, During and After a Spill	
Afternoon:	Introduction to Contingency Planning	
1:15	International Oil Pollution Control Laws and Conventions	
2:00	Contingency Planning Components Movie: Contingency Planning Guidelines	
3:00	Contingency Planning for a Port or Region Movie: A Port Prepared Movie: NEPCO 140	
4:00	National and International Insurance Programs and Funds	

FRIDAY, October 27, 1978

Morning:		Removal of Oil from the Environment/Contingency Planning
	8:15	Removal of Oil from Beaches, Rocky Areas and Marshlands Movie: Beach Restoration Techniques Movie: AMOCO CADIZ Examples
	9:30	Oil/Water Separation and Disposal of Collected Oil
	10:00	Responding to Spill Situations Movie: Some Basic Tools of Oil Spill Control
	11:00	Development of National Plans for Oil Spill Response
Afternoon:		Continuation of Technical Topics
	1:00	Lessons Learned from the AMOCO CADIZ Oil Spill Cleanup
	2:00	Predicting the Movement of Spilled Oil
	3:00	Course Summary and Critique